# IRON AND STEEL ENGINEER

J. F. KELLY, Editor

## CONTENTS

Volume II December, 1925 Number XII

Iron and Steel Exposition ..... II

Editorials ..... III

Selection of Electric Drives for Reversing Mill Motors ..... 479
By L. A. Umansky.

Discussion: Electric Heat Committee Report for 1925 ..... 500

Electric Rolling Mills—By D. W. Blakeslee ..... 508

Items of Interest ..... 512

Coming Meetings and Papers ..... 517

(List of Advertisers—Page IV)

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*ANNOUNCEMENT*

# IRON AND STEEL EXPOSITION

Fuel Electricity Safety Machinery

The twenty-second annual convention and Iron and Steel Exposition will be held at the Hotel Sherman, Chicago, Ill., on June 7th, 8th, 9th and 10th, 1926.

**No space for sale as all booths will be awarded first to the exhibitors who have had displays at our previous Iron and Steel Expositions. Floor plans will be mailed January 1st, 1926.**

## IRON AND STEEL EXPOSITION

706 Empire Building,

Pittsburgh, Pa.

# EDITORIALS

## SELECTION OF OIL CIRCUIT BREAKERS

By E. C. STONE*

In the selection of oil circuit breakers for a given purpose your attention is particularly called to the following:

(1) Interrupting ratings of oil circuit breakers are admittedly maximum ratings, so that breakers cannot be expected to function properly even slightly beyond their ratings. Because of the complexity of factors involved in interrupting short circuits, the conditions on which these ratings are based, have never been clearly defined, and the only proof of such ratings is found in the tests in factory and field under certain conditions which may or may not be equivalent to those to which the breaker is subjected in any particular instance. For example, most field tests have been made on a system having dead grounded neutral, but for the same short circuit current. The duty on a breaker operating on system with free neutral is of the order of three times that on dead grounded neutral.

(2) Every time a circuit breaker opens a circuit through which current is flowing, the arc produced causes burning of contacts, oil carbonization and carbon deposit which effect a definite reduction in the interrupting capacity of the breaker. After a sufficient number of circuit openings, interrupting capacity of the breaker is exhausted and can only be restored by repairing contacts, cleaning inside insulating surfaces and replacing old oil with new.

The loss of interrupting capacity of a breaker, as it operates, may be likened to loss of capacity in a storage battery as it discharges. After a certain duty has been performed the breaker, like the storage battery, becomes exhausted. As the duty is intensified, the life of the breaker is shortened; just as the life of the battery is shortened on heavy load duty. Again, just as the battery may be recharged after its life has been run, so a breaker can be brought back to its original rating by a little simple and inexpensive maintenance.

(3) Interrupting a short circuit of electric current is like stopping a projectile shot from a gun. Added to this requirement is the necessity of taking care of the gas generated by the arc which is very likely to produce a severe explosion. Furthermore, circuit breakers are based on duration of arc during the interruption of two to ten cycles equivalent to 1/30 to 1/6 of a second. If for any reason, the arc duration is materially increased, breaker failure is inevitable. The time factor of safety in a circuit breaker does not exceed 1/6 of a second.

From above facts certain conclusions may very definitely be drawn. They are:

Both from the point of view of safety of operation and cost of maintenance, circuit breakers in any given case should be selected with very liberal rating for the duties which they are to perform. They should be rigidly mounted, and installed in fire and bomb proof compartments, the strength of which depends on the duty imposed on the breaker. In case of outdoor installation, spacing takes the place of compartments. When in service they should be subjected to rigid system of maintenance, involving all parts of the breaker, the mechanism being included as well as contacts and oil. Frequent inspection and test operation of the mechanism is essential in order to be sure of its positive operation at all times, for if it does not function properly the arc may last too long and blow up the breaker.

Rigid mounting comes in here also, since, if the breaker is not so mounted it may be displaced in a way to interfere with operation of the mechanism.

*Planning Engineer, Duquesne Light Co., Pittsburgh, Pa.

## ENGINEERING ACHIEVEMENTS FOR THE YEAR 1925

By W. H. COPE*

WHERE can one find a vocation more interesting or more satisfying than the engineering profession? Where can the pride of accomplishment be more gratifying?

World affairs move more swiftly today than ever before. In no previous age have they progressed so rapidly, chiefly because of scientific developments which have been evolved by the brain, energy, and enthusiasm of the engineer, chemist, physicist and mathematician, all working in harmony toward a common goal—the betterment of mankind.

It is a wonderfully inspiring sight to observe these men in action, particularly when they are brought together in a single organization. One man rarely can develop an idea from its inception to the finished commercial product, ready for markets of the world. The co-operative effort of many minds is necessary, and it is this working in unison, this bringing into play at the proper time the required knowledge, that inspires the observer and arouses his admiration.

The opportunities in the electrical industry are unusual. This is the Electrical Age. Economic conditions are rapidly changing. Developments in the use of electricity command the attention of the entire world because electric power today serves all branches of our modern civilization. It drives our cars, trains, busses and ships; it operates our steel mills, coal mines, oil wells, machine shops, printing

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(Continued on Page 516)

# INDEX TO ADVERTISERS


**A**

Alliance Machine Company 540
Allis Chalmers Mfg. Company 552
American Heat Economy Bureau 549
Appleton Electric Company 544

**B**

Baker R & L Company 549
Benjamin Electric Mfg. Company 527
Bussmann Manufacturing Company 526

**C**

The Clark Controller Company 519
Cleveland Crane and Engineering Co 538
Condit Electrical Mfg. Company 522
Crouse Hinds Company 529
Cutler Hammer Mfg. Company 525
Cutter Electrical and Mfg. Co 533—Cover 3

**D**

De Laval Steam Turbine Company 555
Delta Star Electric Company 543
Doubleday Hill Electric Company 540–541
Duquesne Light Company 520

**E**

Economy Fuse and Mfg. Company Cover 1
Electric Controller and Mfg. Company 536

**F**

The Fafnir Bearing Company 534
Farrel Foundry and Machine Company 535
Fawcus Machine Company 546

**G**

General Electric Company Cover 4

**H**

Harnischfeger Corporation 524
Hyatt Roller Bearing Company 551

**I**

Iron City Electric Company 542

**J**

Johns Manville, Inc 528

**K**

Keystone Lubricating Company 530

**M**

Martindale Electric Company 539
Moloney Electric Company 547
Monitor Controller Company 550
Morgan Construction Company 544
Morgan Engineering Company 558
Morganite Brush Company 542

**N**

National Carbon Company 521
Nichols Lintern Company 537
Norma Hoffman Bearing Corp. 560
R. D. Nuttall Company 532

**O**

Ohio Electric and Controller Co. 554

**P**

Packard Electric Company 566
Pittsburgh Transformer Company 539
Pyle National Company 557

**R**

Reliance Electric and Engineering Co. 561
Rollway Bearing Company 562
Roller Smith Company 545
Rumsey Electric Company 548
F. J. Ryan and Company 523

**S**

SKF Industries, Inc. 559
Smith & Serrell 548
Stackpole Carbon Company 531
Standard Underground Cable Co. 543

**T**

Thompson Electric Company 541
Timken Roller Bearing Company 553
Tool Steer Gear and Pinion Company 546
Trumbull Electric Mfg. Co 550

**U**

United States Graphite Company 547

**V**

V. V. Fittings Company 563

**W**

Edwin L. Wiegand Company 565
Westinghouse Elec. & Mfg. Co 556—Cover 2

**Y**

York Insulated Wire Works of GE Co 545

# *Selection of Electric Drives for Reversing Mills**

By L. A. UMANSKY.†

## FOREWORD—

DURING the last few years you heard several excellent papers dealing with reversing mill drives. Just a short while ago Messrs. Wright, Davis and Needham presented their joint contribution before this Association, and their most complete paper, published in the July, 1924, copy of the "Iron & Steel Engineer," leaves very little to be added to that part of the story. That paper is so complete, indeed, that I may be reproached in advance of wishing to annoy you by merely repeating the statements so ably presented by others. Thus it is squarely up to me to deal today with this topic from still another angle.

I will not attempt to tell you how excellent are the drives built by electrical manufacturers; nor how much operating expense you will save by substituting them for your steam engines; not even how far superior are some design features over others. My task will be much more limited and modest: I will try to show how the capacity of a contemplated drive may be determined; what factors affect the size of the machines, and how they affect it; what the terms "horsepower," "torque," "ampere," etc., mean to all of us, and how they are related to each other in a reversing mill equipment; for, I must admit, this relation is not altogether a conventional one, as encountered in most other machines, and unless one gives this subject a little study, confusion and misunderstanding occur quite frequently.

And then I will sketch out before you briefly, but I trust with sufficient completeness, the procedure of the rather simple calculations which are required, if an attempt is made to deal with the subject in an engineering manner; I will try to justify these calculations and will show that there is no mystery about them; and finally I will present some proof to show how closely the calculations may approach the actual test results.

I am sure that to many of you the subject may not be quite new or unknown. But such is the case with most of Sunday sermons, and still many people go to church—presumably not to learn something new, but rather to strengthen their knowledge of the old. So it may be well for us engineers to follow this example and to go, once in awhile, back to fundamentals.

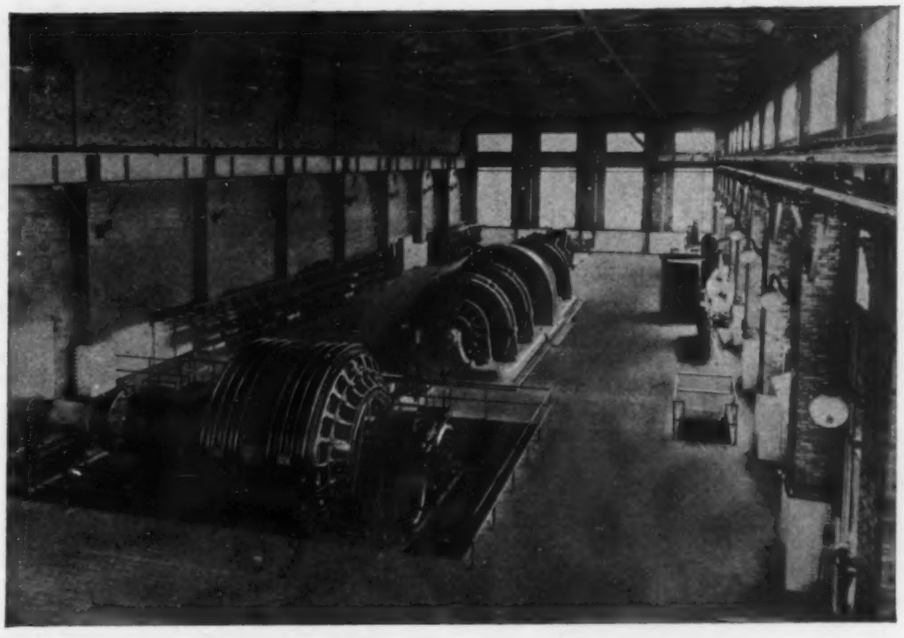

**FIG. 1.—45-inch Reversing Blooming Mill Motor, Tennessee Coal, Iron and R. R. Co., Fairfield, Ala. This is the largest reversing drive in U. S. A.; maximum overload capacity 22,000 HP, at 55 RPM.**

## PART I. THE NATURE OF A REVERSING DRIVE

### Arrangement of the Machines

Of course, all of us know, what are the general lines along which the reversing drives are laid out. Fig. 2 shows diagrammatically a typical arrangement

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of a moderate size drive. The driving motor (M) is always a D.C. machine; the power to it is furnished from a generator (G), driven by an induction motor (IM); the motor-generator set is equipped with a flywheel (FW), the purpose of which is to reduce and to limit in conjunction with the slip regulator the load peaks on the incoming A.C. line. The D.C. machines are separately excited. The main circuit between the generator and the reversing motor is not interrupted during the normal operation, neither is the motor field ever reversed; but by reversing the generator field, it is possible to reverse the polarity of this machine and to reverse therefore the direction of rotation of the motor (M). The

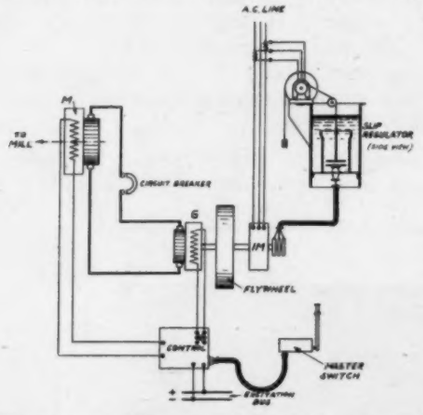


**FIG. 2—Elementary diagram of electrical connections of a moderate size reversing drive. M is the reversing mill motor; G the D.C. generator; IM the slip ring induction motor.**

stronger is the generator field, the higher is the generator voltage, the faster runs the mill motor; its field is kept thus far at its maximum, but after the generator voltage reaches its full value, and it is still desired to speed the motor up, we should begin to weaken the motor field, obtaining thereby an increase of its speed up to the desired and necessary maximum. These operations are done quite easily and in the proper sequence by manipulating a single lever master switch.

### Continuous Capacity

And now, with this picture in mind, let us put forth a question and then let us answer it: if we have a drive like the one shown on Fig. 2, what is its relative capacity at different operating speeds?

Suppose the reversing motor is rated for a continuous capacity of 3,500 H.P., at 50 RPM. When I say **"continuous"** capacity, I mean that this motor can carry a steady load of this magnitude indefinitely long without exceeding a specified temperature rise, like, say 50° C; this also means by the same token that the motor is capable of carrying indefinitely without exceeding the same temperature rise, a fluctuating load, which generates in the motor an amount of heat equivalent to that generated by the steady load of 3,500 H.P.

The voltage applied to the motor, when it runs at 50 RPM is, say 650 volts, and the motor efficiency is 93%.

In the first place, we can readily calculate that when the output of this motor is 3,500 H.P., the input to it is

$$\frac{3500 \times .746}{.93} = 2820 \text{ KW}$$

(1 H.P. = 0.746 KW)

As the voltage is 650 volts, the full load line current is

$$\frac{2820}{650} = 4350 \text{ Amps.}$$

In other words, our motor can carry this current of 4350 Amps. continuously, without exceeding the 50°C. rise. The reversing motors are usually forced ventilated, which means that their cooling is not dependent on the operating speed; if the machine can carry 4350 amps. without overheating at 50 RPM, it can do the same at a lower or at a higher speed. We will indicate this by drawing a heavy horizontal "current" line A, Fig 3, representing the permissible continuous ampere-load at all operating speeds from O to, say 100 RPM.

And, now, if we will force through our machine this current at any motor speed, what torque will this current produce at the motor shaft?

The torque, produced by a D.C. electric motor, depends on two factors: magnetic flux, produced by excitation, and current flowing through the motor armature. Remember, we do not change the ex-

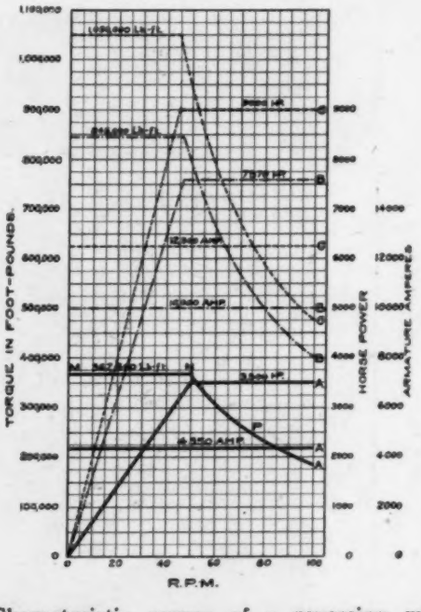


**FIG. 3—Characteristic curves of a reversing mill drive, giving the current, torque and horsepower at different operating speeds. Curves A represent the continuous capacity; Curves B the maximum operating capacity; Curves C the maximum emergency capacity.**

citation of our motor in adjusting its speed between 0 and 50 RPM. Therefore, the magnetic flux remains the same, and with an armature current of 4350 amps. the developed torque is the same for all speeds between 0 and 50 RPM. This is the "constant torque" range of speed.

What is this torque, corresponding to the continuous capacity of the drive? Anyone knows that

$$\text{Torque} = 5250 \times \frac{\text{Horsepower}}{\text{RPM}} \text{ in lb.-ft.} \ldots\ldots (1)$$

or

$$\text{Horsepower} = \frac{(\text{Torque}) \times \text{RPM}}{5250} \ldots\ldots (2)$$

For instance, developing 3500 H.P. at 50 RPM our motor produces a torque of:

$$5250 \times \frac{3500}{50} = 367{,}500 \text{ lb.-ft.}$$

We will draw on Fig. 3, the horizontal line M-N representing this torque for the range 0-50 RPM.

What is the corresponding horsepower? A glance at the expression (2) will remind us what we know so well: the horsepower is proportional to the product of torque and speed. At standstill the motor may develop the same torque of 367,500 lb.-ft., but as long as it does not move, it does not do any work and therefore its power is zero; and we will mark this by starting the HP.-line on the Fig. 3 from 0. As the speed is increased, with the torque remaining 367,500 lbs., the horsepower line A gradually rises, until it reaches the 3500 HP. mark at 50 RPM. (This speed is called the "basic speed" of the drive.)

But now the operator moves the handle of the master switch still further, to run the mill at an increased speed of, say, 60 RPM. He does so by weakening the motor field in the ratio 60:50; for a given armature current the obtainable torque is reduced in the same proportion and is only 284,000 lb.-ft. In other words we "trade" torque for speed, keeping their product the same. This is shown by the sloping part "N-P" of the torque curve, Fig. 3. The horsepower (remember the formula (2)!) remains constant, and we show this by drawing the HP-line horizontally for speeds above 50 RPM. This is the "constant-horsepower" part of the speed range.

The two lines—HP vs. RPM and torque vs. RPM—tell us truly the whole story and explain what we can obtain from our motor at any speed, as long as it draws its rated current of 4350 amperes.

It is quite clear, for instance, that when the roller takes a given draft on a given ingot, he requires a certain definite torque at the motor shaft. Now, in order to produce this torque, the motor will draw from the generator exactly the same current, regardless of whether the mill is driven at 10, 20, 30 or 50 RPM—as long as the motor runs at or below its basic speed (i. e., with full field). This reasoning, simple as it is, is sometimes only reluctantly accepted "for, it is said, is it not right, that when we roll at a lower speed we require less power and, therefore, should not the current be smaller?" To be sure, a slower rolling, with the same draft, requires less power, i. e., less energy spent in a unit of time; when running at reduced speed the motor **does** develop less power and also **takes** less power (kilowatts) from the generator; but the reduction of the amount of the electric power is not made at the expense of "amperes" but of "volts," for we well know that the motor speed is then controlled by the applied voltage, and that the reduced speed means reduced voltage.

When the motor is operating above its basic speed, i. e., with a weakened field, then for a given draft the current is the greater the higher is the speed. In this case the applied voltage is constant, and therefore any required increase of power is obtained at the expense of "amperes." This may limit the taking of heavy drafts at high speeds.

### Basic Speed

Suppose someone suggests "why not increase the 'basic speed,' making it 60 or 70 RPM instead of 50 RPM? Will it not mean that we would extend the range through which the full motor torque is available with the minimum armature current?" Undoubtedly, it will be so; the motor will develop, say the torque of 367,500 lb.-ft. at 60 RPM with only 4350 amps. instead of $4350 \times \frac{60}{50} = 5220$ amps. This will undoubtedly reduce the motor heating. But how are we going to increase the motor speed above 50 RPM without weakening its field? Simply by raising the applied voltage in the same proportion, i. e., by designing the generator for the same current, but for a voltage increased from 650 volts to 780 volts. In other words, we will have (and, generally speaking, will pay for) a larger generating equipment.

The continuous capacity of the motor would be increased from 3500 HP at 50 RPM to 4200 HP at 60 RPM; this increase of capacity does not increase appreciably, if at all, the motor cost; we know that the cost of an electric motor, within certain limits, increases with an increase of horsepower and decreases with an increase of speed; in other words, is a function of the rated torque; in this case we have increased both, the HP and speed and have done so in the same proportion, i. e., leaving the same torque. But a 780 volts 4350 amp. generator is larger than a 650 volts 4350 amp. machine of the same speed, and it will require some extra cost to build one.

If, on the other hand, we reduce the motor basic speed from 50 RPM to 40 RPM, keeping the same available torque at full field, then the motor HP-capacity will be only 2800 HP (50°C.)—40 RPM. The actual motor heating will be increased, because for speeds above 40 RPM the machine will take more current than previously, requiring possibly some increase of motor dimensions and cost. The generator KW-capacity may be, however, reduced somewhat.

Thus the selection of proper basic speed should be always carefully considered when laying out the drive. Different mills may require drives with entirely different basic speeds; for instance, reversing rail and structural mills usually call for reversing drives with higher basic speed than, say, the blooming mills. We will return to this problem later, when making the sample calculations.

### Overload Capacity

You would be right in interrupting me now and in asking: "What about the overload capacity of the drive? Is it not as important to know the maximum available torque and horsepower at various operating speeds as it is to know the continuous capacity?" I will gladly concur in this view, for nowhere in the steel mill practice are the momentary peak loads as violent as in the reversing drives. A motor and a generator designed to meet in every respect the curves "A" of the Fig. 3, may not be at all suited for reversing mill duty, unless they are especially designed to take the imposed peaks without penalty.

We say that the machine will not overheat if it carries 4350 ampere continuously. As the heating is proportional to the square of the load, we may double the current, hold it, say, for 2 seconds, take it off for 6 seconds and repeat this cycle indefinitely,

and still be within the heating limits; in other words; we may double the current, but keep it intermittently for only 25% of the total time; or to increase the current 3, 4, 5 times by reducing the time to 1-9, 1-16, 1-25 of the total. So much for the heating. But trouble may be waiting for us if we go too far in this experimenting; at some current value the motor or the generator furnishing power to it, will show signs of bad commutation; if we still force the issue and increase the current the machines may flash over. No one should blame the machines for that; what is the commutator, after all, if not a device which switches, many times every second, currents of great magnitudes? As any switch has a limit of its interrupting capacity, so has any commutator machine a limit beyond which there is the flashing-over hazard. The machines used for reversing drive duty are usually designed to withstand considerably higher peaks than ordinary industrial motors, but they also have—and should have—their commutating limit.

Suppose "our" machine, which we describe, can commutate 12,500 amps. Possibly we could have gone still higher, say to 15,000 or 16,000 amps. and get away with it once in a while, with a commutator in good shape—but to play safe we will set the circuit breaker to trip at about 12,500 ampere. This means that we do not expect the machine to carry more than this current; this is the **"maximum emergency value."** This current determines at once what is the maximum torque and the maximum horsepower that it is possible to obtain in an emergency from the equipment.

If the motor is shunt wound, it is correct to say, that for a given field strength the torque varies in almost exactly direct proportion to the armature current. If the motor develops 367,500 lb.-ft. torque at 4350 amps. it should develop 1,050,000 lb.-ft. at 12,500 amps.; this maximum torque is obtainable as long as we have full field on the motor. However, the highest full field speed will not be as high as 50 RPM; the low-speed machines, like the reversing motors, have a relatively high internal resistance of the armature; even with 650 volt applied to the armature, but with 12,500 ampere flowing through it, the speed is likely to be about 45 RPM.

We will take again the Fig. 3, and will draw, first of all, the dotted current line C, representing 12,500 amps.; this line is horizontal because it corresponds to the circuit breaker setting and the latter usually remains the same for all operating speeds. Then we will draw the line representing the maximum emergency torque of 1,050,000 lb.-ft. up to 45 RPM; from this point the torque curve will go down and at any speed above 45 RPM, the "emergency torque" (i. e., with current of 12,500 amps.) will be reduced in the same proportion in which the speed is increased. The horsepower curve is calculated directly from the known values of torque and speed; the capacity at 45 RPM and above is 9000 HP.

But this is not the whole story yet! We say that our machines will commutate successfully 12,500 ampere. How often? Let us think again of that comparison between the commutator and a switch or an oil-circuit breaker. If the latter is called upon to open a large current it may do so, say, once or twice at a time, but if this will be its continuous duty, several times in a minute, the switch will deteriorate rapidly; so it is with the commutator. It is not a wise policy to operate too close to the maximum emergency capacity, thereby increasing the wear of the equipment; neither do we want to trip the circuit breaker too often, causing the shutdown of the mill with metal in the rolls. It is advisable to limit the operating current to a lower value, like, for instance, 10,000 amperes; it is easy to provide the control of the drive with current limiting relays which will prevent the operator from imposing on the machines more than say, 10,000 amps, or any other predetermined value. This will "ease" the equipment; it will reduce the wear. The motor and the generator should be good for this current, and when I say "good," I mean just what I say; they should be capable of carrying this current repeatedly, every ingot, day after day; this should be their **"maximum operating capacity."** If the machines cannot meet this condition without damage or excessive wear, it simply means that their maximum operating capacity is smaller. Remember, I do not wish to say here what should be this capacity—but I want to define before you, as clearly as I can, what meaning shall we give to this term, called sometimes "every ingot capacity," or "maximum operating capacity," or (still differently)—"maximum current limit setting capacity."

**Maximum Operating Torque and H.P.**

And, after defining this term, we will assume that "our machine" can operate with the current limit set at 10,000 amperes. This is enough to figure out at once what is the corresponding torque and horsepower.

The maximum operating torque is $367{,}500 \times \frac{10{,}000}{4350} = 845{,}000$ lb.-ft. This torque is available at full field of the motor; the maximum speed (at 650 volts) is, say 47 RPM. This means that the HP at 47 RPM is

$$\frac{845{,}000 \times 47}{5250} = 7570 \text{ H.P.}$$

Above 47 RPM, the available horsepower (at 10,000 amps.) will remain constant, while the available maximum operating torque will be reduced inversely proportional to the increase of speed. We plot the torque and H.P. value against the motor speed by dash-and-dot lines B on the Fig. 3.

Can we reduce the current limit relay setting of our equipment? Will it not be easier on the machines? Undoubtedly this can be done. The only trouble is that we "cannot eat our cake and have it, too"; reduce the current limit and you reduce, in practically the same proportion, the available maximum operating torque and horsepower. Thus, for the machine, which we have used as an example, a current limit setting of 6000 amps. corresponds to a maximum operating torque (at full field) of only 507,000 lb.-ft. and to about 4800 HP (at 650 volts).

**Reduced Output at Maximum Speed**

We have assumed in the preceding discussion that the motor is equally capable of withstanding the same "maximum emergency" and "maximum operating" overloads at all speeds from basic to the highest. This may or may not be the case for various machines. If the speed range by motor field control is rather wide, like, say, 40 to 120 RPM,

then the motor may not commutate such currents as 12,500 amperes or 10,000 amperes as successfully at 120 RPM as it will at 40 RPM. If this is the case, and, if the control is suitably arranged so as to reduce the permissible peak loads at the increased speed, then the characteristic curves of the drive will be similar to the ones shown in Fig. 3A.

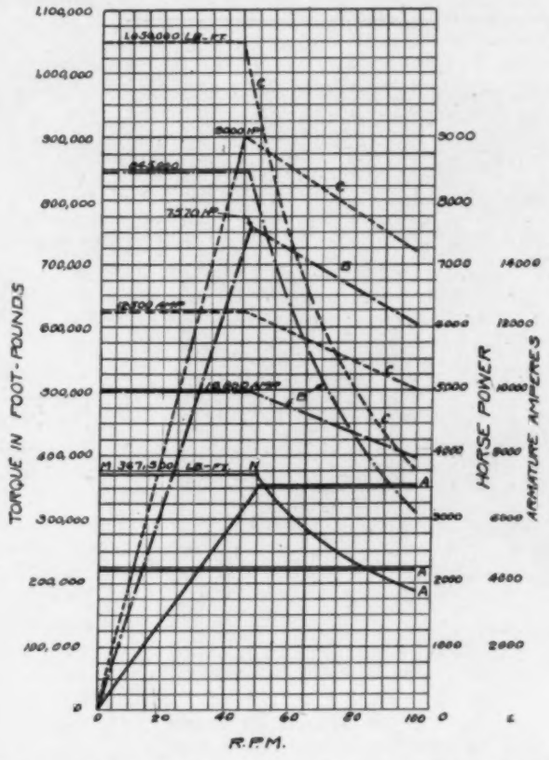


**FIG. 3A.—Characteristic curves of a reversing mill drive with reduced overload capacity at maximum speed (compare with Fig. 3). Curves A represent the continuous capacity; curves B represent the maximum operating capacity; curves C represent the maximum emergency capacity.**

The continuous capacity curves A will be, of course, the same in either case. We will then assume that the "maximum emergency" current C will be 12,500 amperes up to 45 RPM and will gradually slope down to 10,000 amperes at 100 RPM; likewise the "maximum operating" current B will be 10,000 amperes up to 47 RPM and 8,000 amperes at 100 RPM. Naturally, such change in current values will result in a corresponding change of the values of HP and torque above basic speed; compare for this purpose the Figs. 3 and 3A. It is essential, when limiting the maximum operating current to say 8,000 amperes at 100 RPM, not to reduce at the same time the value of 10,000 amperes permissible at 47 RPM; otherwise the entire capacity of the drive will be curtailed by the limitation which may be desired or necessary for the maximum speed only.

From the operating standpoint, a reversing drive represented by the curves Fig. 3A may be considered if the torque requirements during the finishing passes (made at high speed) are reduced in a greater proportion than the speed is increased. Such conditions may exist at some blooming mills, rolling ingots into rather small sections, like 4 x 4 inches; similar conditions are less likely to occur (if at all) at reversing rail and structural or plate mills, where torque requirements at some finishing passes are sometimes as high as they are at the roughing passes.

**Time of Reversal**

There is still another feature of a reversing drive which is brought forth sometimes, especially when it is the question of replacing the steam drive by a reversing motor. You have oftentimes heard the question, or possibly have put it yourself: "How quick can an electric motor be reversed from full speed ahead to full speed reverse?" Builders of steam engines like to ask this question, in vain hope of embarrassing the electrical profession; they claim that the armature inertia of an electrical motor makes it sluggish on reversals.

To begin with, whenever this question is asked or answered, let it be well understood, what is meant by "full speed"; it may mean the basic speed of the motor, i. e., the highest full field speed like 50 RPM in our example, it may mean the maximum possible speed, obtainable by motor field weakening, like 100 or 120 RPM. Then let it be understood just as clearly, whether the reversing is to take place without the metal in the rolls, or under load, and if so, under what load. Loosely applied terms are worse than none.

Suppose we are interested in the time of reversal from basic speed ahead to the same speed reverse, with the mill empty; let us consider for illustration purposes the same 50 RPM motor, previously described.

First of all, we will see whether the alleged magnitude of the armature inertia is such a "bugbear" after all. The 3500 HP-50 RPM motor will have an approximate $WR^2 = 1{,}500{,}000$ lbs.-ft.$^2$; the same machine may easily develop a maximum operating torque of 845,000 lb.-ft. The value of mill friction is negligible, and this torque is available either to accelerate or to retard the motor. Let us recall our lessons in mechanics back in school days; failing this, let us take any handbook and find there the expression

$$a = \frac{308 \times T}{WR^2} \quad \ldots\ldots\ldots\ldots \quad (3)$$

where a — is the rate of change of speed, in RPM per 1 sec.

T — is the torque available for acceleration or retardation.

$WR^2$ — flywheel effect of the armature in lb.-ft.$^2$.

If we insert in that formula the given values for T and $WR^2$, we will readily find that as far as the mechanical inertia is concerned, it is possible to change the motor speed by 173 RPM per 1 second. On such basis one could go from 50 RPM forward to 50 RPM reverse (i. e., obtain a 100 RPM change) in about 0.6 seconds. No drive would reverse that fast, for a good many reasons, but the point which I am making, is that the armature inertia has very little to do with it.

A more serious potential enemy of an electric reversing drive is an inertia of an entirely different nature, not mechanical but magnetic. You remember, of course, that we reverse this drive from 50 RPM to 50 RPM by, reducing the generator voltage,

then by reversing the generator field and by strengthening it again to full value. It is the nature of any magnetic circuit to oppose any changes of its strength, whether we want to weaken it or, more especially, strengthen it; for this reason we may call the phenomenon a magnetic "inertia." It should, therefore, take a little time to "kill" the magnetic flux existing in the generator, and it should take a little more time to build it up again in an opposite direction; this is the real problem when we talk of reversing an empty mill. I should have rather said "it was a problem," for nowadays the electrical engineers know how to design the fields of the machines and how to arrange the control, in order to obtain speeds of reversal far in excess of any needed values. It is evidently useless to insist that the drive be reversed in a much shorter time than is required to manipulate the ingot between passes.

When we reverse from and to the speeds, higher than the basic speed, it is essential, first, to strengthen the motor field, then to weaken the generator field, to reverse it, to build it up again, and then to weaken once more the motor field. This will take, of course, a little more time, but the up-to-date design is so far advanced, that the argument about sluggishness of the electrical reversing drives is really quite rust and worn out.

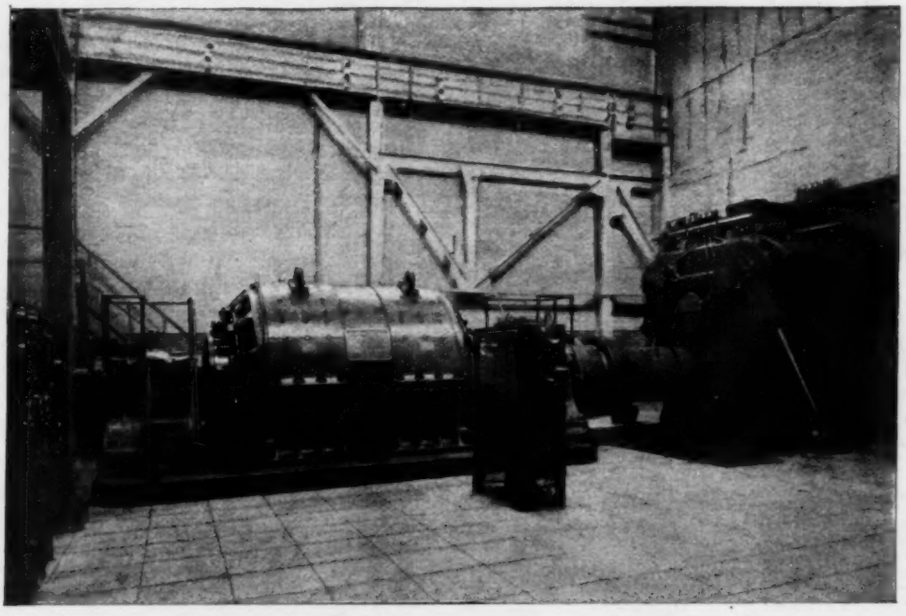

FIG. 4—The 4000 HP (50° C)—80/135 RPM motor, driving the 30-inch Reversing Skelp Mill of the Youngstown Sheet & Tube Co., Youngstown, Ohio. This drive was designed for very quick reversals (see Fig. 5.)

To show what can be done in this line I will give you one or two examples.

The 4000 HP-80/130 RPM motor shown on Fig. 4, driving the 30" Reversing Skelp Mill of the Youngstown Sheet & Tube Co., reverses from 80

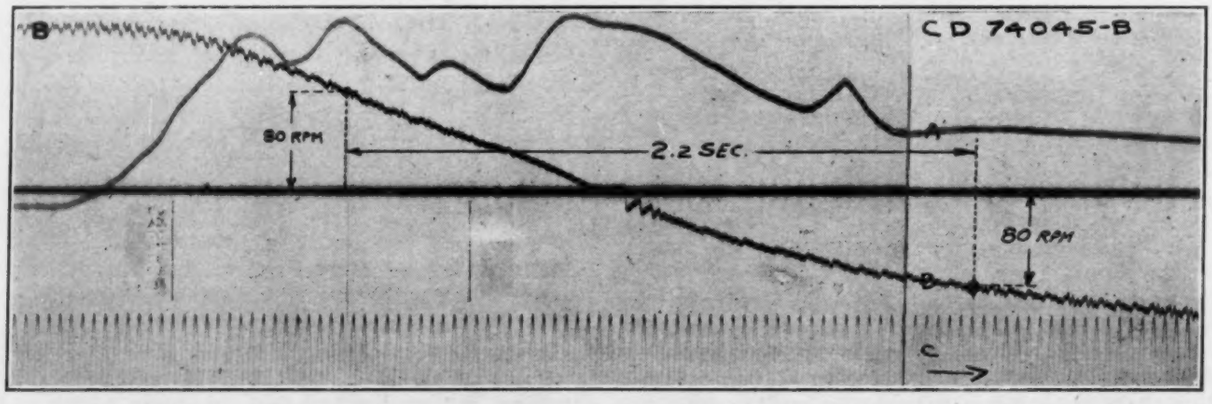


FIG. 5—Oscillogram, recording the speed of reversal of the 4000 HP drive, illustrated on Fig. 4. Curve A represents the armature current; B the speed of the motor; C is the 25-cycle timing wave. Note that the motor reverses from 80 RPM to 80 RPM in 2.2 seconds.

RPM one way to 80 RPM the other way in 2.2 seconds; this particular type of mill requires fast reversals, such was asked for and obtained; the oscillagraph record of this performance is given on Fig. 5. The 6500 HP-50/120 RPM drive of the Trumbull Steel Co., has been reversed from 90 RPM to 90 RPM in 3 seconds. This means an average rate of change of speed of 60 RPM per second.

When we deal with a loaded mill, it is not the "time of reversal" that we are concerned with, but the "snappiness" in picking up and accelerating. The speed with which the generator field builds up obviously does not depend directly on the amount of load; but the maximum possible rate of acceleration does depend on it. It is just the difference between speeding-up your car on the level or uphill; the motor develops so much torque; the more of it is used for overcoming the load (ascending the grade or rolling steel), the less is left for accelerating the car or the mill with the ingot. It is right here, where a machine with a higher current limit setting may differ from one with a lower setting. Let us use again the same machine for example, and compare the 8,000 amps. and the 6,000 amps. settings; they will give 677,000 lb.-ft. and 507,000 lb.-ft. as respective maximum operating torques. If the net rolling work for a given draft and friction require, say 475,000 lb.-ft. torque, then there will be available for acceleration in one case 202,000 lb.-ft. and in other case only 32,000 lb.-ft. By means of the formula (3) it is simple to figure out that with an 8000 amps. setting the mill may be accelerated during this pass if necessary at the rate of 41.6 RPM per second whereas with a 6000 amps setting the maximum possible rate is only 6.6 RPM per second. Here lies the real difference, from the operating standpoint between a machine with high and low maximum operating torques.

### Nameplate Rating

Much as we should give importance to the question of maximum torques, we should not forget that they alone do not always specify the capacity of the reversing equipments. While in some cases the size of the motor and of the generator is determined by the overload peaks, in some other cases the capacity is limited by the heating. There is no excuse in the world for not stating the continuous rating of these drives, just as such rating is stamped on the nameplate of every mill induction motor. The method of rating the reversing drive like, say, "2,000,000 lb.-ft. max. torque, 0-120 RPM," when this is the maximum emergency torque available only for speeds below 40 or 50 RPM, can at best be termed, as "telling the truth, but not the whole truth."

### Shunt and Compound Wound Reversing Motors

Most of you have undoubtedly heard on more than one occasion some live discussions on the subject of "shunt vs. compound wound" motors for reversing mill service. The motors built by the two leading manufacturers in this country differ from each other on this point, and possibly, on this account a good deal of the so-called "sales talk" has been injected in the past discussions. This made me rather reluctant at first to bring the topic again before this Association, but I did not feel like omitting it entirely, just because there was a diversity of opinions. I do not see why this subject should not be dealt with without prejudices and in the light of logic, as it is befitting to this Association.

In case of a shunt motor, the entire excitation is taken from a constant potential exciter bus and its strength is controlled by several field contactors. With a compound motor the total amount of excitation is furnished, partly, by a shunt field, excited in same manner as above, and the balance by an auxiliary field whose strength is proportional to the armature current; for that purpose an additional, so-called variable potential exciter is employed, which is excited by the main armature current; thus this scheme is equivalent to all intents and purposes to a compound wound motor.

The primary purpose of the series field of any compound wound motor is to increase the excitation with the increase of the load; the increase of the field strength increases relatively the torque per one ampere of the armature current and causes the motor speed to drop in an inverse proportion. Obviously the shunt portion of the field should not alone saturate the machine, for if it did so, then the "compounding" feature would not be effective. Therefore, the field of a shunt wound motor, and the shunt portion of the field of a compound wound motor are not at all identical, even though all other things are equal. The latter is smaller, in order to "leave room," in the magnetic sense, for the series field.

Let us take two motors, built alike, except for their field windings, and impose on each an equal rated load; if the designers of each motor used the same magnetic stresses, then the two machines will

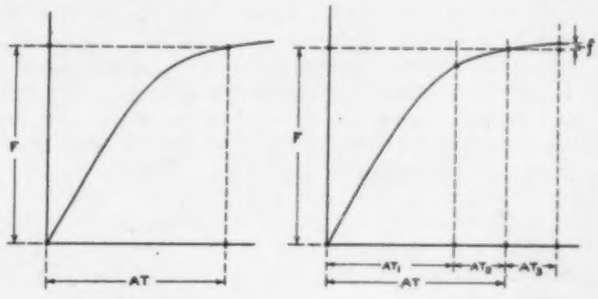


**FIG. 6—Curve a is a saturation curve of a shunt wound motor; AT represents the ampere-turns at full field, and F the corresponding value of magnetic flux. Curve b represents an identical compound wound motor, which has, at the rated load, the same magnetic flux F as the shunt motor; the same total number of ampere turns AT is furnished in part by the shunt field ($AT_1$) and the balance by the series field ($AT_2$). If the load doubles, the ampere-turns of the series field also double (add $AT = AT_2$), but the magnetic flux increases only by the amount f.**

have exactly the same magnetic fluxes; if one is saturated, then the other is saturated, too, and likely, both machines will be saturated at speeds at and below basic, because the designers naturally desire to get all they can out of the iron in the machines. (See Fig. 6.) Once the magnetic fluxes are equal, regardless of how the excitation is derived, both machines will take the same armature current in order to produce the same torque; as long as the load remains at that point we will observe no difference whatsoever between the performance of

either motor: same current, same rated speed. An increase of load will not affect appreciably the speed of the shunt motor, neither will it affect very much in this case the speed of the compound wound motor, because at speeds below basic the fields are well saturated, and a given increase of the ampere-turns of the excitation produce very much less than a proportional change in the field strength (see Fig. 6-b); by the same token, the torque produced by 1 ampere of the armature current will not be materially affected.

However, when we operate above basic speed, i. e., with a weakened shunt field, then the effect of the series field may be made more pronounced. We are then considerably below the saturation point; the **relative** strength of the series field is increased. If, in this case, a heavy load is imposed, then the field will be materially strengthened and the torque per 1 amp. of the armature current will be increased; the speed will drop appreciably. Speaking in terms of a rolling mill, if it runs **above** the basic speed and the roller takes a good-size draft, a compound motor will slow down and will therefore draw less current, as compared with a shunt machine. This eases the work of the electrical machines at a certain sacrifice of the rolling speed. If the roller does not like this drop in speed, he may move his controller handle further, bringing the speed up to the initial value; but if this is done, then the armature current is exactly the same as that of a shunt motor.

If, on the other hand, under the same rolling conditions, the field of the shunt motor is automatically strengthened by a suitably arranged control, then the speed will drop and the armature current will be reduced to exactly the same value as we first obtained with the compound motor.

Thus, the same performance may be obtained, if desired, by the use of either machine. **All other things being equal, the difference between the two systems is not that of the machine design, but of the type of control which is preferred.** The fundamental question is this: "Do we want to reduce the speed to save on current peaks, or is it the maintenance of speed that we want most of all?" Once this question is answered in one way or in the other by the operating man, it is up to the electrical manufacturers to furnish the best control apparatus to meet the given requirements.

This, I think, places the problem where it properly belongs.

I will merely brush aside such unworthy argument that the strengthening of the motor field "acts as a cushion and reduces the mechanical shocks imposed on the mill." Manufacturers of reversing mill drives certainly do not advance such arguments, for they know, as well as all of you know, that the motor will slow down **after,** and **not before** the shock is imposed on the mill; the hammer blow is between the ingot and the rotating **mechanical** parts of mill and of the drive, and this impact lasts an infinitesimal fraction of a second. The field strengthening will help you about as much as a rear bumper in a head-on collision.

## PART II.

### Power Required to Roll Steel

And now we will turn to our next and more immediate problem, that of determining the capacity of a reversing mill drive. That is, we will lay out a definite rolling schedule and will try to determine the capacity of the drive, required to meet this schedule.

Can this be done? Do we know enough about power required to roll steel to make the calculations sufficiently accurate, and to be reasonably certain that they will be closely checked by test after the new drive is installed? In short, is this a proper subject for calculations or should the selection of the drive be left to the "intuition" of the party that makes the selection?

All these questions are logical and not out of place. Unless I can prove to you later on, that reasonably accurate calculations can be made, there is no use of going into details of these calculations.

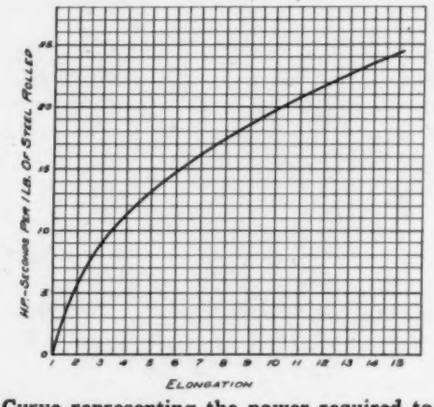


**FIG. 7—Curve representing the power required to roll steel for different elongations.**

What do we know about power required to roll the steel? Theoretically, we do not know a lot about it, but we do know a good deal experimentally. I mean to say, that no one has as yet developed, proved and offered a simple formula for power calculations which would be universally adaptable for any mill, any product, etc. But numerous tests had been made on rolling, say, plates and these test

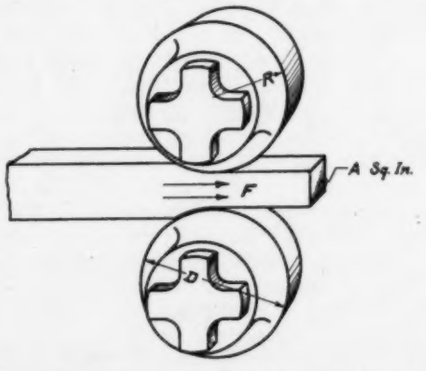


**FIG. 8—Elementary diagram showing a billet in a pair of rolls; R and D are the roll radius and diameter, respectively; F is the tangential force required to push the billet through the rolls.**

results can and should be applied in making calculations on a new proposed plate mill; in the same manner hot strip mill tests may be made use of in selecting new drives for mills of that kind; and, of course, there are many tests which throw sufficient light on transfer of power in a reversing blooming mill.

I hope to have the opportunity and the privilege of describing some time in the future, before this Association, the rather complete tests which I have made on an electrically driven 40" Reversing Blooming Mill; when this opportunity arises, I will outline the method adapted for testing such drives by means of the most sensitive recording device—electric oscillograph; current, voltage, speed, field strength etc., were automatically and simultaneously recorded on a photographic film; and at the same time complete records were kept of the drafts, condition of rolling, temperatures, etc. When such test records are on hand, they can be readily studied analytically, losses estimated, distribution of power justly apportioned, and finally, the results conveniently plotted for calculations of new mills.

In such, or similar manner, a curve like Fig. 7 is plotted. It gives the **net** rolling work, per unit of weight, which work is required for elongating the metal to different values. This is not identical with the KW-hours per ton, which are frequently compared for different mills; the KW-hours per ton include all losses in the machines, mill friction, running light losses, etc., and while eminently important for figuring the **cost** of power per ton of steel, are not readily applicable for determining the size of a reversing drive.

The curves like Fig. 7, however, will be found quite useful for our purpose. For instance, we are making calculations on a blooming mill which uses substantially the same size ingots as the mill which was used in making tests represented by Fig. 7; suppose other conditions, like temperature of steel, etc., are also identical. Let the original area of the ingot be 550 sq. in.; after the 7th pass the elongation is 2.75; after the 8th pass—the area is 170.5 sq. in. and the elongation is 3.22. What is the torque to be developed at the rolls for obtaining the required reduction during the 8th pass?

Let us refer to curve fig. 7. We will see that to elongate the ingot 2.75 times we have to do the

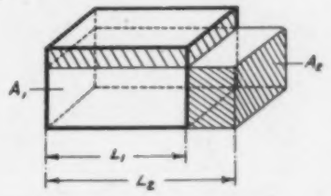


FIG. 9—"Displacement" of metal which is assumed to take place during the rolling. $A_1$ and $L_2$ are the original cross-section and length; $A_2$ and $L_2$ are the cross-section and length of the billet after the pass.

work of 8.28 HP-sec. per 1 lb. of steel rolled; to elongate 3.22 times, the work is 9.55 HP-sec. per 1 lb.; thus the net rolling work done during the 8th pass is 9.55-8.28 = 1.27 HP-sec. per 1 lb. of steel rolled.

If we define the net rolling work done during one pass per each pound of steel as "W" HP-seconds and

**TABLE 1**

**ESTIMATED ROLLING OF 20" x 24", 9000 LBS. INGOTS TO 8" x 8" BLOOMS IN 13 PASSES ON A 40" REVERSING BLOOMING MILL**

| Column No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pass | Cross Section of Ingot | Length | Roll Diam. | No. of Revolutions Made During Pass | Roll Speed | | | Time of Rolling Per Pass | | | | Time Between Passes | Rolling & Friction Torque |
| | | | | | | Enter. | Max. | Deliv. | Accel. | Run | Retard | Total pr Pass | | |
| Before Rolling | | Inches 24x20 | Inch 72 | Inch | | RPM | RPM | RPM | Sec. | Sec. | Sec. | Sec. | Sec. | (Lb.-Ft.) Accl.not Inc. |
| | 1 | 21x20 | 76 | 36 | .675 | 15 | 35 | 30 | 1.0 | .33 | .12 | 1.45 | | 1,280,000 |
| | | | | | | | | | | | | | 2 | |
| | 2 | 18.5x20 | 86 | 36 | .760 | 15 | 35 | 30 | 1.0 | .47 | .12 | 1.59 | | 1,114,000 |
| Turn | | | | | | | | | | | | | 3 | |
| | 3 | 18x18.5 | 95.5 | 36 | .845 | 20 | 40 | 30 | 1.0 | .30 | .25 | 1.55 | | 860,000 |
| | | | | | | | | | | | | | 2 | |
| | 4 | 16x18.5 | 108 | 36 | .960 | 20 | 40 | 30 | 1.0 | .47 | .25 | 1.72 | | 830,000 |
| | | | | | | | | | | | | | 2 | |
| | 5 | 14x18.5 | 123 | 36 | 1.09 | 20 | 50 | 40 | 1.5 | .04 | .25 | 1.79 | | 800,000 |
| | | | | | | | | | | | | | 2 | |
| | 6 | 12x18.5 | 143 | 36 | 1.265 | 20 | 50 | 40 | 1.5 | .24 | .25 | 1.99 | | 800,000 |
| Turn | | | | | | | | | | | | | 5 | |
| | 7 | 15.5x12 | 171 | 32 | 1.71 | 20 | 60 | 50 | 2.0 | .15 | .25 | 2.40 | | 688,000 |
| | | | | | | | | | | | | | 2.5 | |
| | 8 | 13x12 | 204 | 32 | 2.04 | 20 | 60 | 50 | 2.0 | .48 | .25 | 2.73 | | 577,000 |
| Turn | | | | | | | | | | | | | 3.5 | |
| | 9 | 10x12 | 265 | 32 | 2.65 | 30 | 70 | 50 | 2.0 | .41 | .5 | 2.91 | | 635,000 |
| | | | | | | | | | | | | | 3 | |
| | 10 | 8x12 | 332 | 32 | 3.32 | 30 | 70 | 50 | 2.0 | .98 | .5 | 3.48 | | 448,000 |
| Turn | | | | | | | | | | | | | 5 | |
| | 11 | 10.5x8 | 374 | 32 | 3.74 | 30 | 80 | 60 | 2.5 | .64 | .5 | 3.64 | | 248,000 |
| | | | | | | | | | | | | | 4 | |
| | 12 | 9x8 | 442 | 36 | 3.92 | 30 | 80 | 60 | 2.5 | .78 | .5 | 3.78 | | 310,000 |
| Turn | | | | | | | | | | | | | 4 | |
| | 13 | 8x8 | 497 | 36 | 4.4 | 50 | 90 | 80 | 2.0 | 1.15 | .25 | 3.40 | | 219,000 |
| | | | | | | | | | | | | | 10 | |
| | | | | | | | | | | Total time | | 32.43+48= =80.43 Sec. | | |

the cross-section area as A sq. in., then the tangential force F, (Fig. 8), which "squeezes" the metal through the rolls is

$$F = 1870 \times A \times W \text{ lb.} \quad (3)$$

If the active roll diameter is "D" inches, then the torque to be developed at the rolls is, in lb. ft.

$$T = \frac{F \times D}{24} = 78 \times A \times W \times D \text{ lb. ft.} \quad (4)$$

For instance, in our case,

W = 1.27 HP-Sec. per 1 lb.
A = 170 5 sq. in.
D = 31.5 inch.

Therefore the tangential force F = 1870 x 170.5 x 1.27 = 405,000 lbs. and the torque at the rolls T = 78 x 170.5 x 1.27 x 31 5 = 532,000 lb. ft.

The test results may be plotted in still another form. We may express the net rolling work, as calculated from tests, in units of work not per 1 lb. of steel rolled, but per 1 cu. in. of steel "displaced." To explain what is meant by "displacement," I have shown on the fig. 9 by heavy lines the shape of the bloom before the pass, and by thin lines its shape after this pass. It is possible to conceive the process of shaping the steel during the pass, as if the shaded portion of the bloom had been removed from the top and an equal volume added to the end of the bloom; this volume is the so-called "displacement." Although actually the metal is not displaced in such a manner, it is nevertheless assumed that this takes place and the net rolling work may be referred to one cu. in. of "displacement;" this is known as "specific power consumption." The more the metal is elongated, the higher is the specific power consumption; this is plainly shown by the curve, fig. 10. (This curve does not represent the same set of conditions which correspond to fig. 7.)

It does not make much difference which of the two methods is used. Either curve is, after all, but a means to record the test data for future use. If the test data are the same, or of the same reliability and accuracy, then either method should give the same value of the amount of net rolling work to be spent during each pass, for a given reduction at that pass. And once this is known, it is simple to calculate the torque at the rolls, as we have done in the expression (4).

I hardly need to say, that once we know the torque (T) developed at the rolls, and know the speed (N rpm.) at which they run, the horsepower is determined in one stroke of a slide rule; just remember the expression (2): Horsepower = $\frac{\text{Torque x RPM}}{5250}$ Sav at anv time the torque is 300,000 lb. ft., and the speed is 40 RPM. The horsepower is $\frac{300{,}000 \times 40}{5250} = 2{,}290$ HP.

## PART III.

### Calculation of a Reversing Mill Duty Cycle Rolling Schedule

We have outlined so far—briefly and necessarily far from completely—the fundamental features of the D.C. machines comprising the reversing drives and the method of estimating the power required to make a given reduction. And now we should try to apply these fundamentals to estimating a duty cycle of a reversing drive. There is nothing like dealing with definite figures of a given case, instead of talking in generalities.

Let us take as our choice a 40" Reversing Blooming Mill. The blooming mills are the mainstay of a steel plant; they are the most numerous users of reversing drives, and the 40" size seems to be the most popular. The selected mill will be a busy one: it will take, say, 20" x 24", 9,000 lbs. ingots and will roll them down to 8" x 8" blooms at the rate of 1 ingot every 80 seconds; this means that a maximum of 180 Gross Tons will pass through the mill per 1 hour. Assume a yield of 88 per cent, and 600 working hours per month; this means that the possible net monthly output is 95,000 Gross Tons. As a matter of fact, our mill will undoubtedly roll some slabs, or will use a few ingots of different size; delays, like shortage of steel, might occur, making it necessary for the mill to catch-up with the production. But let us assume, that the drive should be designed to operate steadily and continuously on the above duty cycle, and let us see afterwards what, if so designed, it will do in emergency cases. First of all, we will find out how the mill operators expect to roll the 20" x 24" ingot to the 8" x 8" bloom, i. e., what will be the drafts at each of the 13 passes, what are the working diameters of the rolls, etc. We, electrical men, usually have not much to say as to how the steel should be rolled. At least we will assume in this case that the pass diagram is given us, and we are told to be guided by it.

The reductions per pass are tabulated in the column (2) of the attached calculating sheet. (Table 1). The rolls diameter is 36" in the bull-head section, and 32" in the grooved passes; the manipulation of the ingot is also shown in the table.

From the known reductions, and roll diameter, and from a suitable power curve similar in character to but not necessarily the same as the one shown on Fig. 7 or Fig. 10 the net rolling torques were calculated in the manner previously described (See formula 4), and are listed under column (14). These

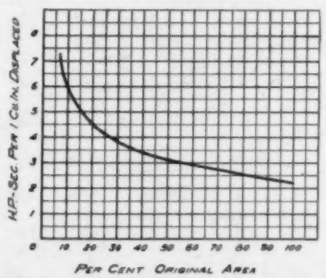


FIG. 10—Specific Power Consumption for rolling steel.

values also include the mill friction torque, assumed in this case at 20,000 lb.-ft., so that column (14) gives the total torques developed at the motor shaft. In this tabulation I have purposely neglected the effect of the ingot taper and few other refinements in which we indulge ourselves once in a while; I have done so in order to simplify the analysis, at a little sacrifice of "hair-splitting" accuracy.

The torques given in the column (14) do not include the inertia forces, and we will see later on how to take care of this point.

From the calculated length of the steel in each pass (column 3) and the known roll diameter (4), it is simple to figure out the number (or fraction) of revolutions made by the rolls during the active (i. e. rolling) part of each pass, (column 5).

**Rolling Speed**

Now we have to select the rolling speeds and then to figure out the time per pass, etc. As we must complete the rolling of one ingot in a specified time and should have a certain margin before the next ingot, the proper speed values should be judicially selected, in agreement with the reversing mill practice; here, again, the test data are of great importance, if a new drive is considered, as they give a positive proof of what is actually done on mills of like character. The selected speeds should then be, of course, checked by the "cut-and-try" method against the available time, as it will be presently described.

Experience shows that the roller usually starts the mill in the proper direction, accelerates the rolls up to a certain moderate speed, forces the ingot into the mill and then accelerates the drive with the metal in the rolls. After reaching a certain speed permissible for a given pass and section, the operator slows down the mill somewhat and delivers the metal on the table at the opposite side. The mill is then brought to rest, and is accelerated in the opposite direction up to the proper entering speed for the next pass, etc.

Thus, we distinguish three separate values: "entering" speed, "maximum" or "running" speed, and "delivery" speed. The "entering" speed should be selected rather low, to minimize the mechanical shocks and to insure a good grip of the rolls on the metal. The "maximum" speeds for each pass, as selected in this example, are moderately low for the roughing passes and conservatively high for the finishing passes. The "delivery" speed is usually less than the maximum speed; a too high delivery speed may possibly mean a time loss, due to the overtravel of the ingot on the delivery table; on the other hand it is advantageous, also from the standpoint of time-saving, not to slow down the mill excessively with the metal still in the rolls; thus a compromise delivery speed is selected to give the best all-around results. The speed values selected for this example are tabulated in columns 6, 7 and 8.

How fast should the mill be accelerated and retarded? The higher are the rates of acceleration and retardation, the more is the mechanical strain imposed on the mill; we will also show later on that a higher rate of acceleration increases the work of the electrical machines. But we should not forget, that the faster we go from the entering speed to the maximum speed, the higher is the average rolling speed for a given maximum speed, and therefore the "faster" is the mill. A study of speed-time charts of reversing drives is again the proper source of information for calculations on a new drive. In our case we will assume rather moderate values: rate of acceleration—20 RPM per one second; rate of retardation—40 RPM per one second. We will further assume in our calculations that these average values will prevail throughout the duty cycle; this is of course, only approximately true, but is close enough to make the calculations sufficiently accurate. A further "splitting of hair," and more mathematically correct calculations of speed-time curves are feasible, of course, and sometimes they are essential; but I will spare your time today, will use the reasonable assumptions and we will then see where we land.

How can we figure out the time per pass, as long as the roll speed changes during that period? This, in itself, is quite a simple problem, although a little tedious.

Let us take, for instance, the pass No. 8. **Firstly,** how long does it take to accelerate from 20 RPM to 60 RPM? If the rate of acceleration is assumed at 20 RPM per second, then this period will last just 2 seconds. Insert this value in the column (9). **Secondly,** how long will it take to slow down from 60

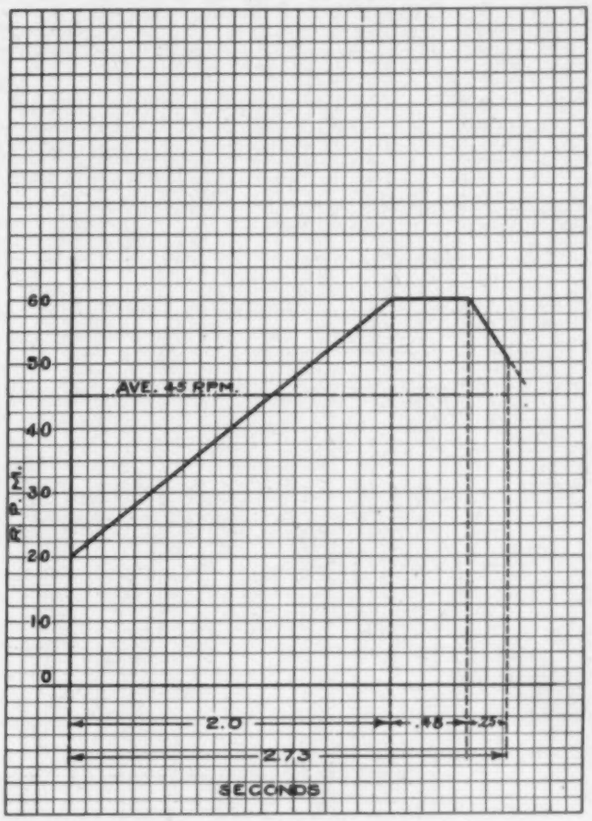


**FIG. 11—The speed of the reversing blooming mill during the pass No. 8 (see Table 1). The mill accelerates with metal in the rolls from 20 RPM to 60 RPM in 2 seconds, runs at 60 RPM for 0.48 sec. and slows down in 0.25 sec. to 50 RPM for delivering the steel.**

RPM to 50 RPM? As the rate of retardation is 40 RPM per 1 second, the change of speed by 10 RPM will occur in 0.25 sec., see column (11). **Thirdly,** how long will the mill run during this pass at the maximum speed of 60 RPM? This we will determine by the following reasoning:

Remember, during this pass, the piece is 204 inches long and the 32" rolls will make 2.04 revolutions, see column (5) of table 1. Now, during the acceleration (assumed to be uniform) from 20 RPM to 60 RPM, the average speed obviously was 40 RPM (i.e. $\frac{40}{60} = \frac{2}{3}$ revs. per second) and this period

lasted 2 seconds: therefore, the rolls turned

$$\frac{40}{60} \times 2 = 1.33 \text{ revolutions.}$$

Likewise during the 0.25 sec. of retardation the average speed was 55 RPM $= \frac{55}{60}$ R.P.S. and therefore the rolls turned

$$\frac{55}{60} \times 0.25 = 0.23 \text{ revolutions.}$$

Therefore during the constant-speed-running the rolls will have to make

$$2.04 - (1.33 + .23) = .48 \text{ revolutions.}$$

At the speed of 60 RPM, this will require

$$.48 \div \frac{60}{60} = .48 \text{ seconds}$$

Thus the total time of pass No. 8 is

$2.0 + 0.48 + 0.25 = 2.73$ seconds (See column 12)

This may be illustrated by the diagram Fig. 11, which

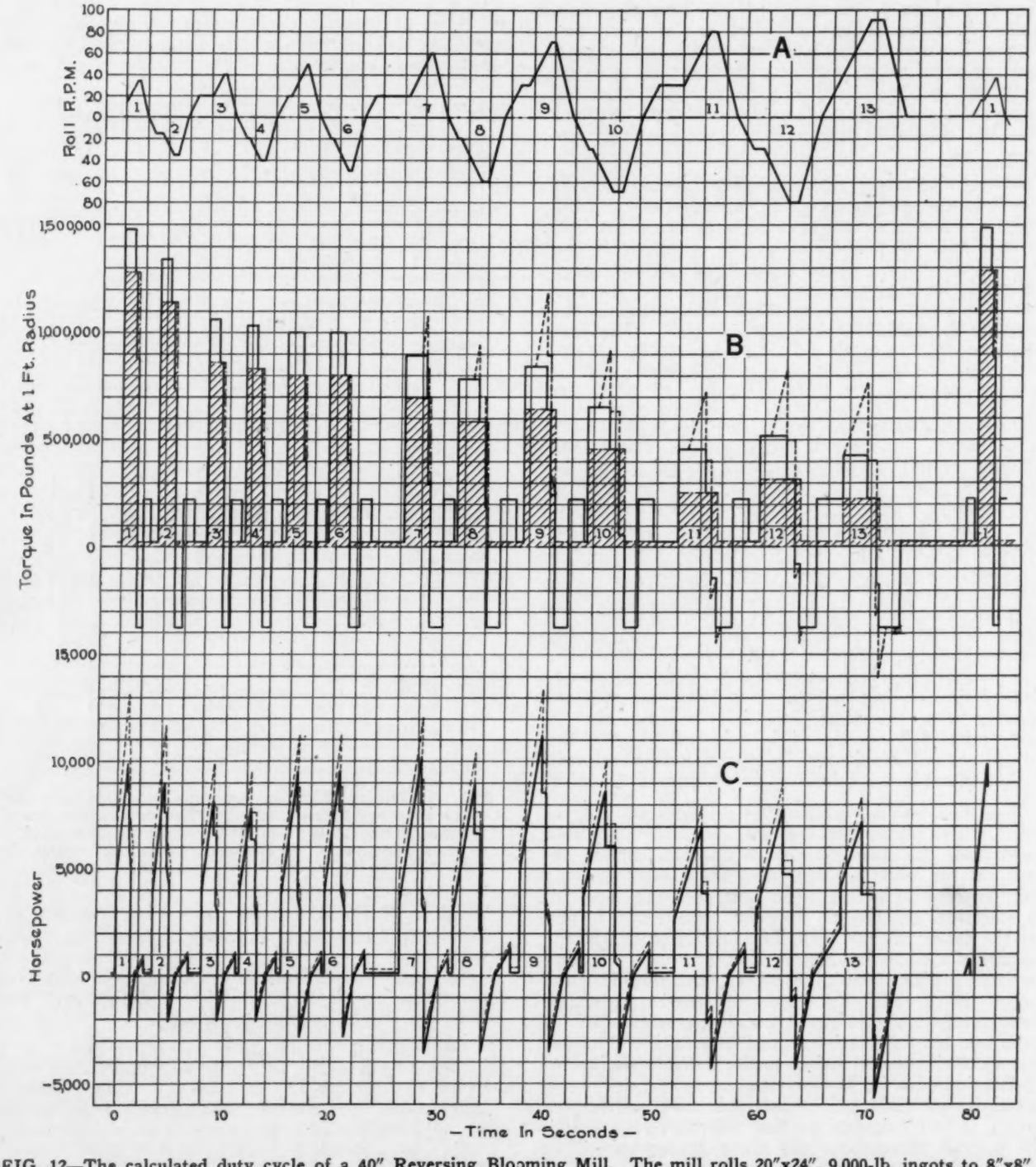


FIG. 12—The calculated duty cycle of a 40" Reversing Blooming Mill. The mill rolls 20"x24", 9,000-lb. ingots to 8"x8" blooms in 13 passes, as described in Table I. Curve A shows the mill speed; B the motor torque; C the horsepower developed by the drive.

indicates the speed variation during the pass No. 8. The mean speed (in RPM) is

$$\frac{\text{(No. of Revs.)}}{\text{(Time in seconds)}} \times 60 \text{ or}$$

$$\frac{2.04}{2.73} \times 60 = 45 \text{ RPM.}$$

This example clearly shows that in order to maintain a given mean speed during the pass the roller must approach a considerably higher maximum speed. The shorter is the pass, the more difference there is, generally speaking, between these two values.

### Duty Cycle Curve

It is best to represent our calculations of the mill duty cycle graphically. Fig. 12 is the chart on which I have done it. The upper curve (A) gives the RPM of the mill during the process of rolling one ingot. This diagram shows that the complete rolling will be comfortably done in 70.5 seconds, and that ingots may readily follow each other every 80 seconds, as scheduled. Thus, the selected values of speed were not far off. The next curve (B) represents the torques that should be developed by the drive at any time to roll the steel and to overcome the mill friction; (this curve encloses the shaded area).

### Effect of Inertia Forces

It is now time to explain how I have figured out and how I have considered the effect of inertia forces, which are always on hand whenever the mill speed is changed, not to speak of the case when the mill is reversed.

We have already had the opportunity to recall the fundamental formula (3) which gives us the value of the accelerating torque "T" required to increase the speed of a rotating body with a flywheel effect "$WR^2$" lb.-ft.$^2$ by "a" RPM every 1 second;

$$T = \frac{WR^2 \times a}{308} \qquad (3)$$

It is self evident that when the body slows down, and its speed is reduced uniformly by "a" RPM every second, then not only we should not apply any extra torque to it, but on the contrary the body itself will set free a torque of T lb-ft. figured out exactly in accordance with the same formula (3).

Now in our case the "rotating body" is the armature of the reversing motor and other rotating parts of the mill; when the ingot is in the rolls it should also be accelerated or retarded. A motor which is likely to be used for driving this mill (here we are guessing, of course, on the basis of past experience, but we will check our guess later on) will have together with the rotating parts of the mill an approximate $WR^2 = 3{,}000{,}000$ lb.-ft$^2$, (note incidently, that the 9,000 lbs. ingot applied at the roll radius of 18" = 1.5 ft. will be equivalent of only $9{,}000 \times 1.5^2 = 20{,}300$ lb.-ft.$^2$, a well nigh negligible amount as compared with 3,000,000). When we accelerate the mill at the rate of 20 RPM per sec., we must develop an extra torque of (See formula 3).

$$T_a = \frac{3{,}000{,}000 \times 20}{308} = 195{,}000, \text{ sav } 200{,}000 \text{ lb-ft.}$$

When we retard the mill at the rate of 40 RPM per sec., we "deliberate" or obtain from the armature inertia an assisting torque of

$$T_R = \frac{3{,}000{,}000 \times 40}{308} = 390{,}000, \text{ say } 400{,}000 \text{ lb-ft.}$$

We will therefore add 200,000 lb-ft. to the torque curve fig. 12 for any time that the mill is accelerated, and will subtract from it 400,000 lb-ft. for any time that it is retarded, at the assumed rates. Thus the complete torque-values to be developed by the motor are arrived at, and are plotted by the heavy solid lines on the curve sheet. You will also note the dotted lines on the torque diagram, beginning from the 7th pass, but of these I will tell you later.

### Horsepower-Time Curve

To make the story more complete I will plot the curve (C) which gives the horsepower developed by the motor at any time during the rolling; this curve

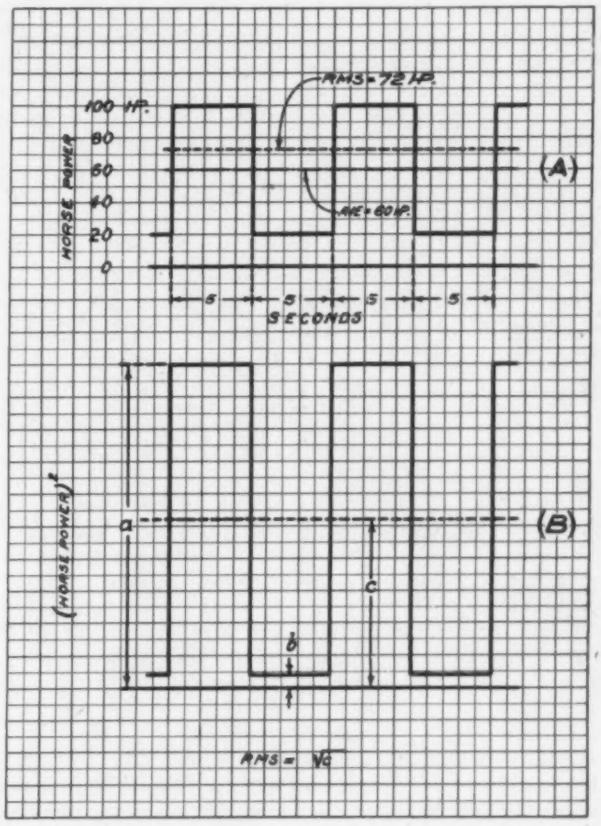


**FIG. 13—A represents the duty cycle of a motor drive, the average load being 60 HP. The curve B represents the heating of the motor, proportional to the second power of the load; the average ordinate (c) corresponds to the average heating load (root mean square), which is 72 HP.**

is not as essential as the other two for determining the size of the reversing motor, but it is illuminating in its own way.

The HP-values (see the heavy lines) are simply obtained by multiplying "torques" by "RPM" and by dividing the product by 5250. Several points of interest may be noted in connection with the HP-Curve C. We will observe, for instance, that although the torques are the highest during the first few passes, the HP-output maintains its high value

even during the middle passes when the combination of the torques and RPM is still high.

Secondly, the HP-Curve lies mostly above the center line, but at times it crosses it, and lies below; the physical meaning of this is, that the reversing motor at these instances is not receiving any electrical power which it usually converts into mechanical power, but on the contrary, it is then converting its stored kinetic energy back into electrical power. The energy previously spent for accelerating the drive is now regenerated or **returned,** less a certain amount of transformation losses. It is just this point that our steam drive friends forget quite frequently in comparing their goods with the electric reversers.

If we integrate the HP area on this chart, under the heavy solid lines we will obtain the average motor shaft output. It should be exactly equal to the total of the net rolling work done on the 9,000 lbs. ingot, plus the friction work, if this total work is spread uniformly over the entire period. This average value is about 2050 HP.

Now, that we know what is the expected machine performance, let us select a drive to meet the duty cycle. We examine the curves and decide that in this case it is well to have the motor full torque available up to, say, 50 RPM. (We will further justify this selection in the latter part of the discussion). This means, that we will increase the mill speed up to this basic value, by raising the generator voltage. Above it the speed will be increased by motor field weakening with the corresponding reduction of available torque.

### Heating of the Motor

Can we adopt for our drive a motor of a continuous capacity to correspond to the average HP-value calculated above as 2050 HP? Such an idea, if it occurs, should be chased away most mercilessly. A motor so selected will roast and will burn-out in no time. The simple reason is that the **average** load is **not** necessarily the **mean heating load**. Suppose you have a motor that runs, say, for 5 seconds with 100 HP load, then for another 5 seconds with 20 HP load, and so on (see Fig. 13). The average load is 60 HP, but the heating of the machine is proportional to the second power of the load, and not to the load itself. The upper curve (A) of the Fig. 13 shows the load cycle just described and the average load 60 HP; the lower curve (B) represents the heat generated in the motor during the various phases of the cycle, i. e., the ordinate "a" is proportional to the square of the 100 HP load, or 10,000, while the ordinate "b"—to the square of the 20 HP load or only 400. The amount of heat is therefore represented by the area under the curve (B); the average heating value "c" is therefore proportional to

$$\frac{(10{,}000 \times 5) + (400 \times 5)}{10} = 5200$$

Such heat would be generated by a steady load of $\sqrt{5200} = 72$ HP; we call such **equivalent heating load** the **Root Mean Square (RMS) Value** of the duty cycle. When the load is absolutely steady and constant, the average and the RMS value coincide; but as long as there are peaks exceeding the average, the RMS is invariably higher than the average. For instance, in the above example it is 20% higher; in a number of cases it may be 100% or 200% higher.

When we have a drive which runs part time as a motor and part time is re-generating or pumping the energy back, then the gap between the RMS and the average values still further widens. Obviously, for calculating the average load, the energy that is "pumped back" is subtracted from the energy that was "sent" to the motor; but the heat, that was produced in the machine while the latter was regenerating, unfortunately is **added** to, and is **not subtracted** from the heat produced in the machine while it was "motoring." Thus in calculating the RMS-Values the "negative" loads should be turned upright, and considered just like any "motor" load.

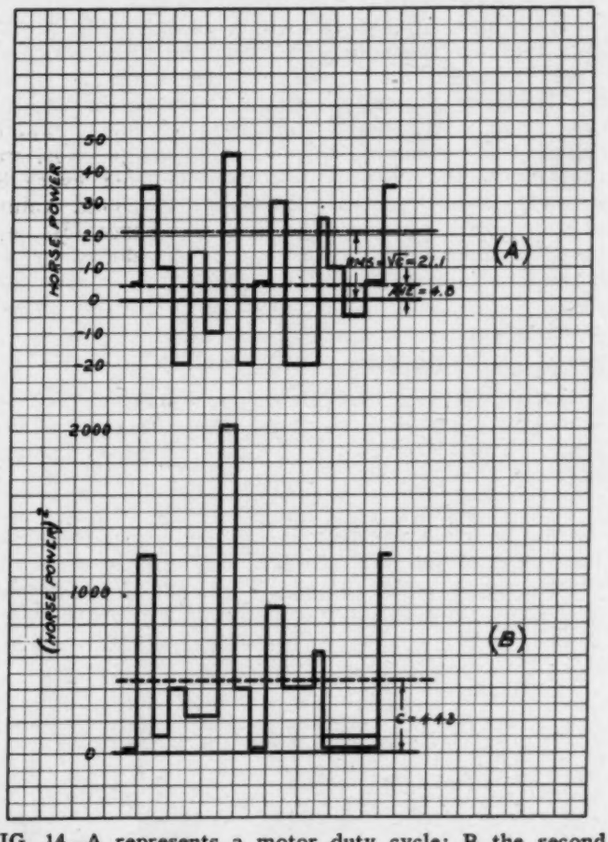


**FIG. 14—A represents a motor duty cycle; B the second power of the load. The root mean square load is 4.4 greater than the average load.**

For instance, with a duty cycle like shown on Fig. 14, the average load is 4.8, but the RMS = 21.1, i. e., 4.4 times greater.

But here the story does not end. Suppose we were to take the horsepower curve (C), fig. 12, determine in some way the RMS-Value of this load, taking in consideration all nice points just mentioned. If we would have done so, and would not make any mistake in the process of calculations, we would find out that this value is close to 3700 HP. Is it correct to say that a 3700 HP motor is big enough for this work? Decidedly not. We have gone only part of the way, but not the whole way to the proper solution, and I will tell you presently where we have failed.

Just take, for example, pass No. 2. The maximum HP-load during this pass is 8920 HP; it oc-

curred when the mill speed was 35 RPM. This means that our motor is running below its basic speed of 50 RPM; the speed of 35 RPM is obtained by lowering the generator voltage below normal; therefore if the motor under such conditions still develops 8920 HP, it requires proportionally more amperes than it would at full voltage. As it is the armature current that contributes mostly to the heating, it may be truly said, that 8,920 HP at 35 RPM heats the motor just as much as about 12,800 HP at 50 RPM. It would be right to call, therefore, this fictitious load of 12,800 HP—the "equivalent HP-load"—equivalent in respect of heating to the actually existing load of 8920 HP.

Thus we see that for speeds below the basic speed, the HP-load curve (C) is not the proper measure of the heating. And it is well to reason in this manner: "If it is the current that heats the motor, why not use as a measure of heating the torque values, which are proportional to the current as long as the motor field is fully excited?" This is exactly what we should do in such case: determine the RMS-value of the torque for all speeds **below** basic.

And then what? After we begin to increase the speed by motor field weakening the torques calculated and plotted on the curve B are no longer proportional to the current; the latter is as much increased as the field is weakened. And by the same token, we should introduce the term of "equivalent (heating) torque."

Note the dotted lines on the curve B, Fig. 12. They represent the calculated equivalent torques; for instance, developing 400,000 lb-ft. at 70 RPM the motor draws as much current from the generator as when developing $400{,}000 \times \frac{70}{50} = 560{,}000$ lb-ft. at 50 RPM. Naturally, for speeds 50 RPM and below the terms "equivalent torques" and actual torques shown by heavy solid lines, coincide. In other words, the corrected torque curve, with parts shown in dotted lines, is a good measure of the mean effective heating of the motor. At last we are on the right track!

It is a rather tedious and pains-taking job of taking any long and broken curve, like the one of our duty cycle, and to calculate, point by point, its RMS-value. But it has got to be done, just the same; long calculations requiring 2-3 days may be just as important—if not more so—than simpler calculations lasting but 2-3 hours. Luckily, however, there is an instrument which enables us to determine a RMS-value of any complicated curve in a few minutes. (See Fig. 15.) You simply lay your curve on the table and trace the curve by the pointer of the instrument—just as we do with an ordinary planimeter when working on indicator cards—and read the result on the dial. Then—2 or 3 strokes of a slide rule, and the work is done. (*)

I have done so with our torque curve B, and the result is, that its RMS-value is 535,000 lb-ft. In other words, the motor heating produced by calculated load during the 80 seconds period is equivalent to the heating that would be produced by a constant load requiring a steady torque of 535,000 lb-ft. during the same period. Now, for a 50 RPM motor, this is an equivalent of a load of

$$\frac{535{,}000 \times 50}{5250} = 5100 \text{ HP.}$$

Incidentally, note that this RMS-value is 2½ times as large as the average value of the HP-curve (C); you see clearly how misleading would it be to select the motor on the basis of "average values."

**Test Results**

And now I wish to offer you a proof, to which you are entitled, to show that all the lengthy calculations, if based on proper test data, are reliable and manifoldly worth the time spent in making them.

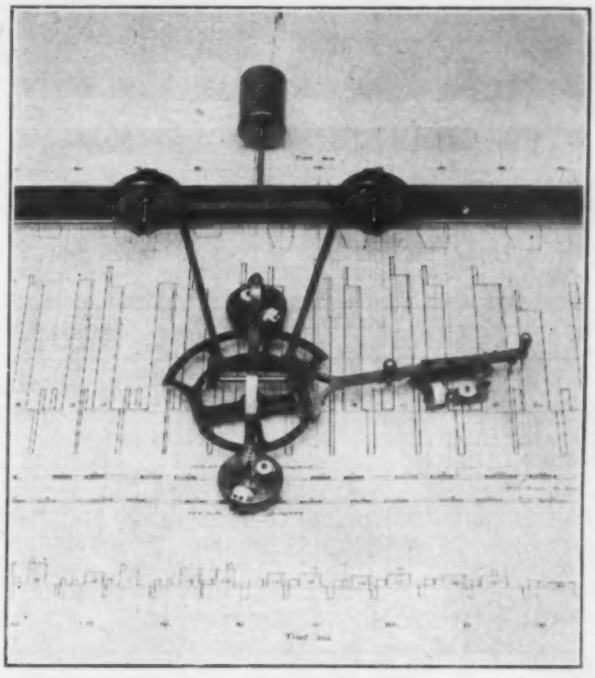

**FIG. 15—Amsler's Mechanical Integrator, which may be advantageously used for determining quickly the root mean square or the average heating load of a duty cycle. This instrument is used in the same general manner as a conventional planimeter.**

Several 20" x 24", 9,000 lbs. ingots were **actually** rolled on an electrically driven 40" mill to an 8" x 8" bloom in 13 passes and in about just as much time per ingot as we have assumed in our example. While the rolling was going on, an electrical oscillograph faithfully recorded on an unfolding film all fluctuations of current, voltage, speed, etc. To be sure, the roller did not know anything about the theoretical calculations; he was not told, how to roll steel, but even if he were told, it is very doubtful that he would be willing or able to be guided by the nice curves which we have just plotted. The records show, that he sometimes would take more draft at one pass and less at the other, than we have calculated. On the whole, he accelerated and retarded the mill faster than our tabulation shows, the actual average rates being 23 RPM/Sec. and 47.5 RPM/Sec., instead of 20 RPM/Sec. and 40 RPM/Sec. During some passes he had minor difficulties in getting the steel in the grooved section of the rolls, and this re-

(*) See "Mechanical Computation of Root Mean Square Values," by L. A. Umansky, Journal A. I. E. E., October, 1923.

sulted in a little extra waste of power. But when all is said, it is the result that counts, and the result is such:

The oscillograph records were laid on a table, and the RMS-value of the current was calculated with an integrator. One test gave 3790 Amps, another 3720 amperes. Now, for the given voltage and excitation of tested machines, and for the known efficiency of the drive, these current values correspond to 5550 HP and 5450 HP. respectively or 5500 HP on the average. This is not an altogether bad check on the theoretically arrived at value of 5100 HP.

### Selection of Continuous Capacity

But let us get back to our immediate subject; we have not decided yet what size motor should be selected for our mill. Shall this be a 4000 HP, 5000, 6000 or 7000 HP machine? All depends on what we call "horsepower," and on what rolling conditions prevail at our mill.

An electrical motor may be capable of developing continuously, say 1000 HP with a temperature rise of 40°C; the same machine is likely to develop continuously 1200 HP with a temperature rise of 50°C. Now, the machine is actually the same, although one man may call it 1000 HP and another 1200 HP; if the temperature rise is not specified, in each case, then such practice is bad, negligent and misleading.

It seems to be the consensus of opinion of the majority of steel mill men that the electric motors should be selected to meet their continuous duty on 40°C rise basis. Once a machine is selected and actually designed, as a 1000 HP-40°C rise motor—it matters very little whether it is called and nameplated in that manner, or whether it is rated 1200 HP-50°C rise; the point is, that in each and every case, speaking of horsepower, the temperature rise should be most emphatically specified.

If the rolling schedule, which we have assumed for our mill in making calculations, may prevail indefinitely, or at least a great portion of the year or a month, then it is probably wise to so select the motor, that it will meet this duty cycle on 40°C rise, i. e., to design it as at least a 5100 HP-40°C machine, which is an equivalent of something over 6000 HP at 50°C. If, on the other hand, the rolling schedule represents the "program maximum" for many years to come, i. e., the mill may operate at it for a turn in a week, or for a week in a month, etc., then it may be too conservative to meet such schedule on 40°C rise basis; it may not be considered bad to have the machine heat up to 50°C above the air for such small proportion of time, if for the rest of the time the work is easier. Remember, that a machine selected to operate successfully from the standpoint of heating, for one turn, will usually be large enough to work harder for one hour or so, because such intensive hours alternate with more slack hours. All these factors should be carefully and judiciously weighed at this instant. A motor that is too small for the job—is the curse of a mill; but there is no use of overmotoring the mill, by piling up successively several margins: First, when preparing the rolling schedule; secondly, when specifying the motor size; lastly, in having the designers put some extra margin in the machine itself. I believe it right to estimate beforehand, as near as we can, the maximum future requirements and to include them in the calculations, without leaving too much for that gap which is rather vaguely called a "safety margin."

Now, I will assume that our mill will be a busy one, that the tonnage will be large, and that the above rolling schedule will prevail most of the time. Suppose, I am a conservative man and that I want to have the temperature rise of my steadily working machines not more thant 40°C. It is likely that I will select then a machine good for, say, 6500 HP or 7000 HP at 50°C rise.

The basic speed of the motor was selected at 50 RPM; the maximum speed for our schedule was 90 RPM, but it is nice to be able to roll some lighter sections at a somewhat higher speed. This can be

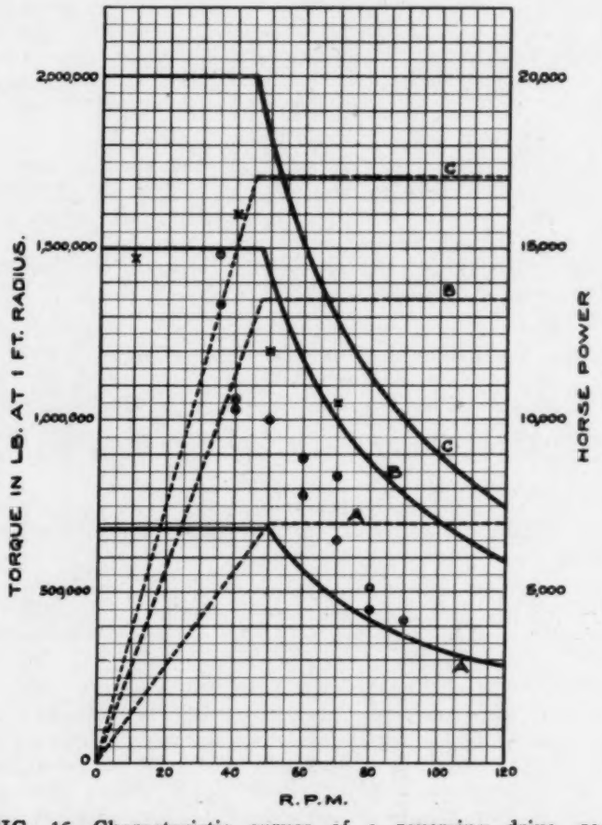


**FIG. 16—Characteristic curves of a reversing drive selected for meeting the duty cycle shown on Fig. 12. The circles represent the calculated torque values to be developed by the motor while rolling at different operating speeds.**

easily provided by further motor field weakening up to say 120 RPM; this gives a 2.2;1 speed by field control, and such range is not excessive. Of course, if we go too far in that direction, it might become more difficult to commutate peak loads at the highest speed.

Let us show the characteristics of the selected machines by means of curves like those shown on Fig. 2. We plot the HP and torque curves A, Fig. 16, representing the continuous capacity of the equipment. The meaning of these curves is believed to be quite clear.

**Selection of the Maximum Torque Values**

We will presently turn our attention to the question of overload capacity of the equipment to be selected. From the duty cycle curves, Fig. 12, or from the Table 1, we will read the torques to be developed by the motor and the corresponding maximum speeds, and will mark these values by circles on Fig. 16. These torque values should include, of course, the amount required for armature acceleration.

In the face of these calculated values it is reasonable to wish that the selected motor be good for delivering repeatedly—every ingot if so required—a maximum operating torque up to about 1,500,000 lb ft. with full field, and proportionately less with the weakened field. We plot such torque curve B, Fig. 16, and note that the "circles" are well within the operating capacity of the drive.

We should always remember, however, that although the rolling of 20"x24", 9,000 lbs. ingots to 8"x8" blooms was assumed to be typical for this particular mill, and that it is satisfactory to determine the **continuous capacity** on that basis, there may be cases when larger ingots are rolled, or when taking of heavier drafts is essential; a few ingots of carbon content higher than normal may be rolled, for one hour or so; although there may not be enough of them to overheat the motor, still, the lower temperature of the steel may require larger torques.

From a study which I have made once on a similar mill, I have selected a few points, marked with crosses on Fig. 16. Some of these values (also including the armature acceleration at 20 RPM/Sec.), lie beyond the torque curve B; for instance, there is a torque value of 1,600,000 lb. ft. at 40 RPM; the corresponding rolling torque (less acceleration) is, 1,400,000 lb. ft. If the current limit is so set, that the operating torque is limited to 1,500,000 lb. ft. then there will be only 100,000 lb. ft. available for acceleration, and therefore the motor can be speeded up only at the rate of 10 RPM per sec. There is no harm in this, if such pass occurs only once in a great while. If the necessary rolling torque itself (i. e. less acceleration), is larger than 1,500,000 lb ft., then the operator should be expected to reduce the draft accordingly, for it may not be wise to increase the capacity of the drive just for such a seldom occurrence.

The tentatively selected value of 1,500,000 lb. ft. is over 200% normal, and if we think that this is correct, we should require the electrical manufacturers to make the machines good for delivering such maximum operating torque, every ingot without wearing out the machines excessively.

The emergency torque value should be considerably higher, of course. Remember, that not far beyond the emergency torque may lie the danger zone of the potentially possible flashover. Neither do we want to operate too close to the circuit breaker setting, which corresponds to the maximum emergency torque. We will not be far off, if we select the value of about 2,000,000 lb. ft., which is close to 275% normal. This value is also plotted on Fig. 16, together with the corresponding HP curves.

Such curve sheet is as important as anything, whenever we want to specify to the electrical manufacturers what drive we need, or when they describe what drive they recommend.

**Selection of Basic Speed**

It is now necessary to justify the selection of the basic speed of drive at 50 RPM. As was mentioned previously, we have plotted on Fig. 16, by circles and crosses, the torque values which the drive should develop at various operating speeds. The location of these points shows that up to a speed of 45-50 RPM the machine should be capable of developing its maximum torque; at higher speeds the torque requirements are less and it is, therefore, satisfactory to obtain them by motor field weakening. Thus it seems that 50 RPM is about the right basic speed for this drive. By bringing it lower, we

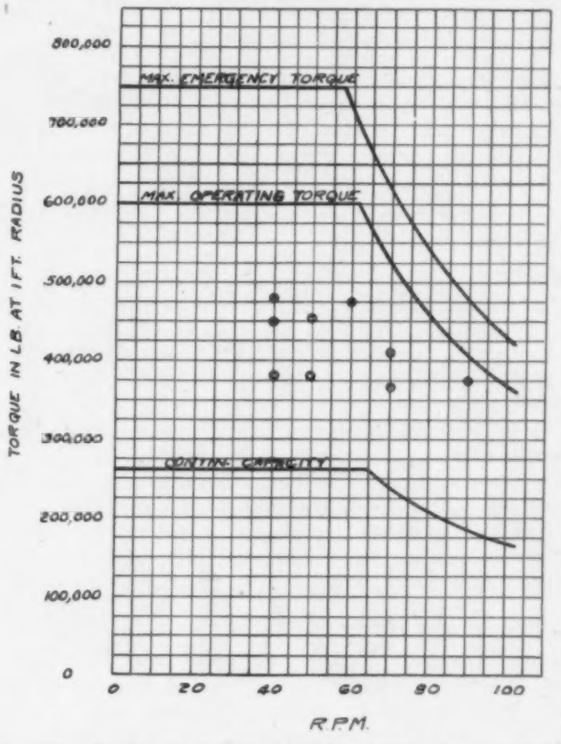


**FIG. 16A—Study of torque requirements of a reversing rail mill (roughing stand) rolling reheated blooms to rail blanks. A relatively high basic speed should be recommended for such drive.**

will reduce the torques available at speeds above basic, if such torques as calculated are required, then the rolling would have to proceed at a reduced rate. Furthermore, the heating of the motor will be greater, because a larger current will be drawn to produce a given torque at speeds above basic (the values of "equivalent torques" will be increased); this means that, possibly, a machine of larger physical dimensions (and cost) will be employed. These shortcomings may be more serious than any possible saving on the KW-capacity of the generator. In our case we should not, therefore, go below the basic speed of 50 RPM.

On the other hand, in this case, we would not be justified in raising this speed much higher; the required torque values are within the operating torque curve; the motor heats up to about its capacity, i. e., it is used efficiently. There is no use, therefore, to increase the basic speed much above 50 RPM. because there is nothing to off-set the corresponding increase of the generator KW-capacity and cost, which will result from it.

The same conditions may not prevail for other reversing mill drives. For instance, the figure 16A represents a study made on a reversing rail mill. It is advisable to select for such drive a reversing motor with a basic speed of about 65 or 70 RPM in order to maintain sufficiently high values of torque at high mill speeds. If a lower basic speed is selected, it is still essential to provide the same value of torque at high speed, which means that the motor will have more torque than necessary (and than will ever be required) at and below the basic speed; in other words, such machine will become more expensive and will represent a larger investment than may be justified for such drive. Thus, for mills of this kind a higher basic speed results in an equipment which is much better balanced in all its parts.

The importance of selecting the proper basic speed of a reversing drive can not be emphasized too much. As soon as the torque values for different passes are calculated, they should be plotted against the selected speeds, as has been done on figures 16 and 16A, and the basic speed should be judiciously selected.

### Generators

As to the generators, it is obvious that they should be in each and every respect adequate to the motor duty. The same current that heats the motor, heats the generator. A 7000 HP motor with a 92-93% efficiency requires approximately 5600 or, say, 6000 KW generator capacity. The generators should be good, of course, for the same peak current values, which are required in order to develop the maximum "operating" and "emergency" torques. The curve sheet, Fig. 16, should represent not only the reversing motor itself, but the whole reversing **drive**, including both motors and generators.

### Capacity of the Induction Motor

The induction motor driving the generators is not subjected to the swings of loads of a magnitude anywhere near the peaks in the D.C. circuit. It is the purpose of the flywheel to absorb a large part of the imposed peaks, by giving away some of its stored energy; during the intervals between passes the induction motor accelerates the wheel and restores some energy in it; when the mill is slowed down rapidly, so that the reversing motor "pumps back" into the generator, the latter is running as a motor and is also tending to speed the flywheel up; in this manner, the much-talked-of accelerating losses of an electric reversing drive, are salvaged in their greater part.

If we should take the curve C on the Fig. 12, which represents the horsepower-output of the reversing motor, and should add to each point of the curve the corresponding losses in the reversing motor, and in the D.C. generator, we would obtain a new curve (shown by dotted lines), showing the power to be delivered to the generator shaft jointly by the induction motor and the flywheel. In an ideal case, with a sufficiently heavy wheel, the motor could be made to carry just the average load under the dotted line, which load is about 2,650 HP. It is not economically possible, however, to build flywheels of such weight, and a compromise is usually obtained; the flywheel and the slip regulator do **not equalize** the load, but they merely **limit** the load to a value somewhat higher than the average. Fig. 17-a represents a high-speed wattmeter chart record input to a flywheel set; Fig. 17-b represents an input to the same set, the chart speed being only 3 inches per hour.

As long as the load is not strictly uniform and constant, the RMS-value, i. e., the minimum motor capacity, is higher than the average load; an analysis of a large number of graphic charts recording the input to the induction motors driving the flywheel sets of reversing blooming mills, show that the RMS value is usually not more than 10% higher than the average, if that much higher. You will remember that the calculation of the capacity of the D C. reversing motor had shown that in that case the RMS value is 2½ times greater than the average; this is because the peak loads in the D.C. circuit are not equalized nor limited, and also because part of the time the D.C. machines are operating at reduced voltage. This reasoning explains the question, which is sometimes quite puzzling to a non-electrical man; "why is it," he asks, "that the motor driving the flywheel set, which motor furnishes the power to roll steel, and which also covers all transformation losses—why the rating of that motor is often smaller than the continuous rating of the reversing D.C. machine?"

It is impossible to make a general statement whether the induction motor rating should be 50% or 75% or 100% of the reversing motor continuous rating. The following conclusion appears logical, however; the size of the induction motor driving the set depends primarily on the average load, while the size of the reversing motor depends not only on this average, but also on the magnitude and frequency of peak loads, which increase the RMS-value far above the average; therefore, the shorter are the passes, the more frequent are the reversals, the larger becomes the capacity of the reversing motor, as compared with that of the induction machine; on the contrary, mills like reversing rail and structural mills with longer passes have, we may say, less pronounced "reversing features," and there the rating of the induction motor is relatively higher than for blooming mills.

The calculation and plotting of a curve representing the input to the induction motor, with a flywheel of an admittedly **smaller** capacity than is required to **completely equalize** the load on the incoming line—requires a certain mathematical skill, considerable patience and time. It is a study of interaction of a flywheel and of an induction motor; the well known Gasche formulae are not directly applicable for this case, because the load is not represented by rectangular curves, and the secondary resistance is permanent for a part of the time, and is variable for the rest of the time. I went through such calculations several times and believe that, in the long run, they are a luxury, and not a necessity. Therefore, from a practical engineering standpoint we may dispense with them, and I will outline a short-cut method of checking the selected size of the induction motor.

Take the average value of the area under the dotted HP-line on curve C, Fig. 12. It is, as we have said, the average combined output of the induction motor and flywheel In our case this average is calculated as 2,650 HP. As the flywheel is obviously not generating any energy, in the long run, this average must be furnished by the motor; in

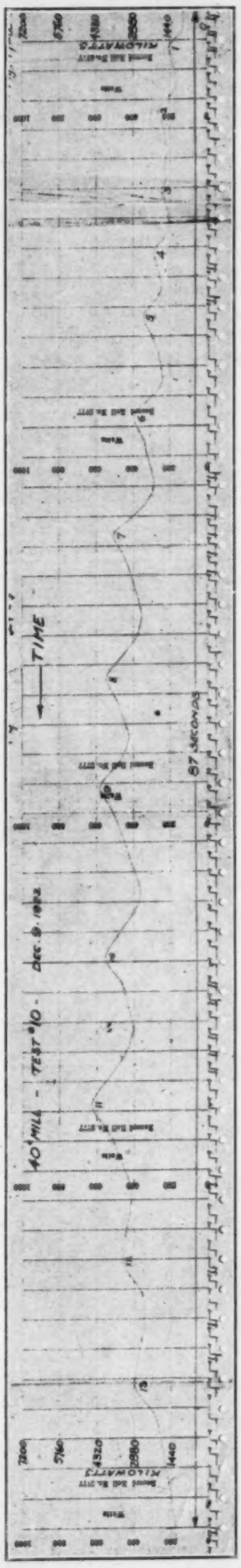


FIG. 17-a—High-speed Wattmeter chart, recording the KW-input to a 3750 HP induction motor, driving a flywheel motor-generator set of a 40" Reversing Blooming Mill. This chart covers rolling of one ingot in 13 passes in about 87 second. The average integrated load is 2650 KW; the root-mean-square load (or the average heating load) is 2700 KW.

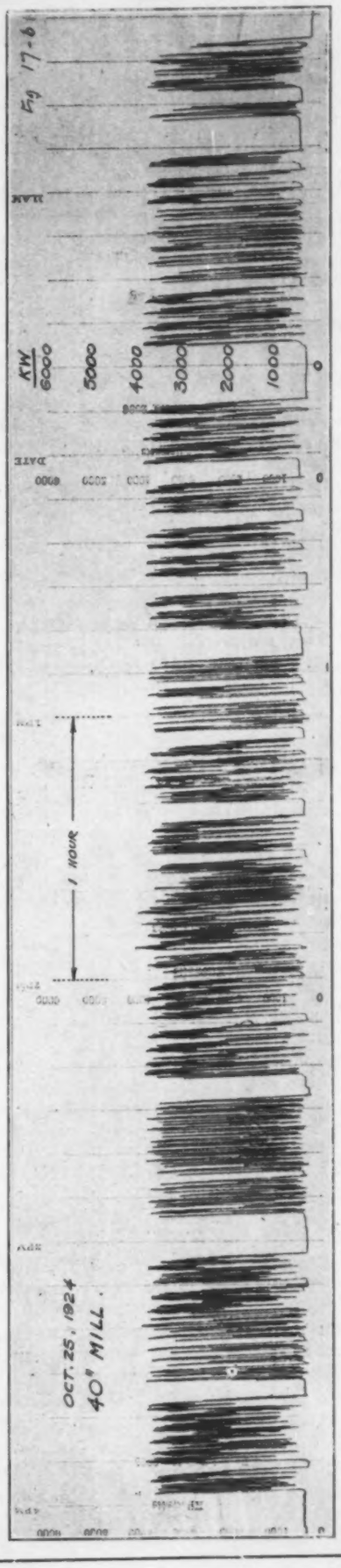


FIG. 17-B—Normal speed Wattmeter chart, recording the KW-input to 3750 HP induction motor driving a flywheel motor-generator set of a 40" Reversing Blooming Mill; the chart speed is 3 inches per hour. The rolling conditions are similar to the ones represented by Fig 17-a, except the slip regulator setting was reduced. This chart serves merely to indicate the maximum demand and the load limitation controlled by the slip regulator.

addition to it, the motor must cover the friction and windage of the flywheel itself; let us say, these losses amount to 50 HP. Still further, we will have to pay a "commission" for the benefit derived from the performance of the flywheel and the slip regulator; this "commission" is the slip regulator loss. Say, the average slip is 10%; the average motor output is 2,650 + 50 HP = 2,700 HP, therefore we will assume that the slip regulator losses are close to 10% of 2,700 HP, i. e., 270 HP. In other words, the total equivalent average load of the motor is close to 3,000 HP. Let us estimate the difference between the average and the RMS-values as 10%. This brings us close to rating the motor at, say, 3,300 HP; if we are to meet this on 40°C basis, we will call for a motor of, say, 4,000 HP-50°C rise.

We said, that the flywheel cannot be economically built large enough to completely equalize the load; in other words, we want to limit the size of the wheel to some reasonable value, and will then see how that will work out. Say, we set the limit in this case at a 50 tons wheel, running at 375 RPM. Such wheel, if properly proportioned, may have a total stored energy of about 175,000 HP seconds at 375 RPM. The amount of energy stored at different lower speeds is given by curve Fig. 18. If we desire to limit the minimum operating speed to 85% synchronous, then the maximum drop of flywheel speed is 15%; this means that not more than 28% of the total wheel energy (about 49,000 HP-seconds) may be extracted from the flywheel.

How low may the speed go? Why specify 85%, not 80%, nor 75%? Will this not permit the use of a lighter wheel, or smaller induction motor, or both? In the first place, the lower is the minimum operating speed, the more difficult it is to maintain the proper value of the generator voltage; if we go too low, the generators have got to be made considerably larger; it is a poor economy to save on the induction motor and to spend more on the more expensive D.C. generators. Secondly, the larger is the slip, the larger become the slip regulator losses; here, again, it may be a false economy to "skin" the flywheel and, on the other hand, to waste power in the slip regulator. Thus, this is a question of give-and-take; good judgment is needed, and a little figuring is helpful.

We will end here today our calculations of the required capacity of the machines comprising the reversing drives.

## PART IV. SELECTION AND TESTING OF THE EQUIPMENT

### "If I Were a Steel Mill Engineer"

I have often thought of what I would do in selecting a reversing drive, if I were representing the interests of mill operators, and not those of an electrical manufacturer. May I be excused for outlining here the program which I would select in such a hypothetical case?

Of course, I would get, first of all, from my rolling mill department complete information regarding the contemplated rolling program and data on the mill itself. Tonnages per month, per turn and per hour, sizes of ingots and blooms, number of passes, reductions, roll diameters, etc.—all these points, which were so important in making the duty cycle calculations, would be collected, in order to make the picture of the mill requirements as clear and definite as practically possible.

With these data on hand, I would try to lay out the duty cycle corresponding to the maximum continuous requirements. To be sure, I would need the data on power required to roll steel of the kind and size in question; I might or might not have these data on hand. In the first case I could, of course, make the preliminary figuring in about the same way, as was done here tonight; in the latter case, I would have either to invite a consulting engineer, or ask for advice of electrical manufacturers who presumably have the necessary power data. If several manufacturers submit their recommendations as to the horsepower, torque and speed of the reversing drive, I would compare and line up these recommendations; if a manufacturer "A" suggests, say, a 6,000 HP drive, and another manufacturer "B" is recommending an 8,000 HP outfit for the same mill, to meet the same requirements, then I would draw the conclusion that either they interpret my requirements differently, or they define the "horsepower" in different terms, or their test data on which the calculations are based are not equally good. I would not tolerate such discrepancy; if I am convinced that my mill requires an 8,000 HP drive, then the manufacturer "A" would have a hard job of explaining and of proving why he thinks that his 6,000 HP outfit is big enough to do the same work; if he convinces me that 6,000 HP is big enough, then I would have to call the other manufacturer, and let him explain, why he wants to take my good money for the extra 2,000 HP. And, of course, I would have in store a similar set of questions regarding the maximum operating and emergency torques, current limit settings, generator capacity, etc. Briefly, I would take the stand, that although I may be at first in doubt as to what size equipment is needed for my mill, I have no doubt whatsoever that for a certain definite rolling program at my mill, I need so much horsepower and so much lb. ft. torque, regardless of the make of the electrical machines. I would sift the various recommendation, would decide which rating is more nearly correct, and would then invite the several manufacturers to quote on equipments of the same continuous and overload capacity. Unless I do so, I would consider myself as failing in my duty to the steel mill management

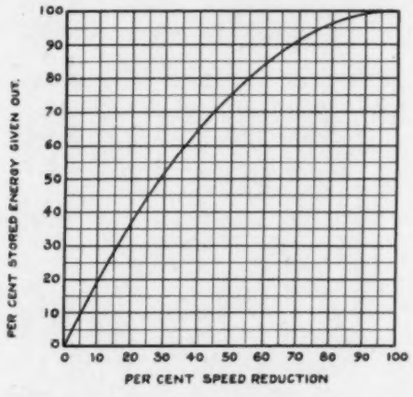


**FIG. 18—Stored energy of a flywheel at different operating speeds, expressed in per cent of the total energy at the maximum speed.**

who entrust me with the selection of the right kind of drive for the right price.

**Testing of the Equipment**

But, say, the order is given, the machines are built, and they arrive at your mill. Machines are installed, connected. You examine the nameplates and see that your requirements are met on this point, and that all machine ratings are clearly and completely given, as called for in the specifications. How do you know that the machines will actually deliver the continuous output without overheating? How do you know that they will not flash over

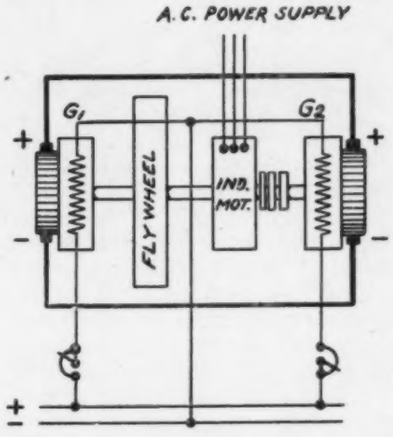


**FIG. 19—Diagram of connections for a "circulating current test" of two generators of a flywheel set.**

when developing the "emergency" torque? It is a common occurrence, that many drives are designed for rolling conditions which will exist only some years after the date of purchase. Consequently, right after the installation there may not be even steel enough to test the drive by actual rolling. It is just the same as buying a high-powered automobile, guaranteed to carry you at 70 miles an hour, or to pick up from 5 to 50 miles in 7 seconds, and then not to have a place to try it out except on crowded city streets infested with traffic policemen. If the dealer who sold you that car had given you the "guarantees" with certain mental reservations, i. e., promising more than the car is good for, then he will thoroughly enjoy your embarrassment in not being able to test the car out; in fact, he might have thought, that on account of the traffic laws, you will never go to 70 miles, that you will be limited to 40, and will still think that you got a "70-mile-an-hour car." On the other hand, an honest dealer will like to take you in his car to a speedway in order to show you the quality of the machine. I do not assume too much in saying that the electrical manufacturers belong to the second, rather than to the first kind of dealers. They should be glad to demonstrate to you that their machines are up to their ratings and guarantees. But where is the "electrical speedway," suitable for testing out the machines, comprising the reversing drive?

Due to the large capacities that are usually involved, and to the low speed of the reversing mill motors, it is very seldom possible to connect the motor to the adequate full load and to take a heat run test, not to speak of maximum overloads. Such conditions may hardly be fulfilled either at the manufacturers' plant nor at the mill. There are ways, however, of creating an artificial load, which is fully as effective for testing purposes, as the actual load.

If we have a double-unit drive, consisting of a two-armature motor and of a flywheel set with two generators, then it is not difficult to arrange for such a test.

For instance, the Fig. 19 shows the two generators $G_1$ and $G_2$, arranged for the test. The respective terminals of $G_1$ and $G_2$ are connected to each other, positive to positive, negative to negative. The generators are separately excited and are driven by the induction motor IM. If the two fields are equal, then the generated voltages of $G_1$ and $G_2$ are equal, and no current flows through the machines. By slightly weakening the field of $G_2$, or by strengthening the field of $G_1$, or by both methods, a current may be caused to flow in the direction of the arrow. By properly adjusting the two fields, it is possible to control the amount of current, and in this manner to impose "normal load" on the machines. This is the so-called "circulating current method"; the generator $G_1$ acts as generator, while $G_2$ runs as a motor and converts the energy into mechanical power on the common shaft, and so on. Both machines run at full load current and at practically normal voltage. The induction motor only supplies sufficient power to cover the transformation losses in the two machines, and, of course, the flywheel and its own losses.

By further unbalancing of the fields of $G_1$ and $G_2$, a still heavier load may be imposed on the machines. In this manner, it is possible to check the

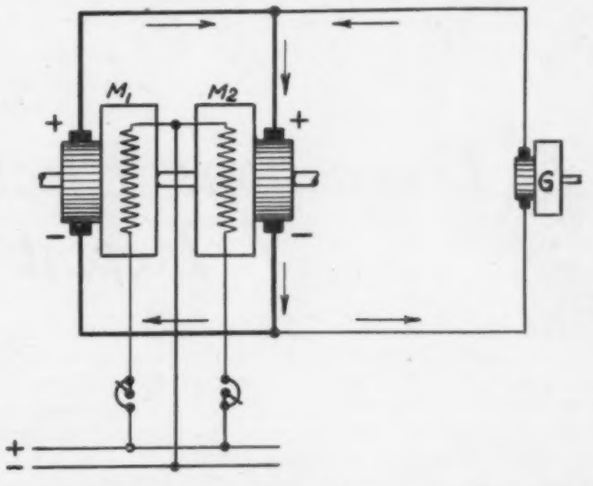


**FIG. 20—Diagram of connections for a "circulating current test" of a double-unit motor.**

commutation at currents corresponding to the maximum operating and emergency torques of the drive.

In a similar manner a double armature motor may be also tested, see Fig. 20. If the field of $M_2$ is somewhat weaker than that of $M_1$, then $M_2$ runs as a motor, drives $M_2$ as a generator, and receive the power back from $M_2$, less the transformation losses. The generator $G_1$ supplies additional power to cover these losses. Heat run and overload tests may be thus imposed, and the capacity of the machine checked.

With a single-armature machine, it is much more difficult to arrange such simple, but effective tests.

If the manufacturer happens to build two identical equipments at the same time, then it is feasible to couple the two machines together, and to test them out at the factory in the just described manner.

If, however, such coincidences do not occur, then we have to face a more difficult problem. It is possible to drive the reversing motor by means of a relatively small auxiliary motor, and to short circuit the armature of the large machine; the excitation is, of course, very much reduced, and is only sufficient to force the normal current through the armature and the pole-face and commutating windings. The losses which are present during such artificial test consist of: $I^2R$ (or copper) losses, friction

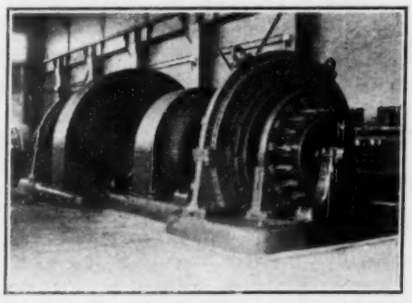

**FIG. 21—Flywheel motor-generator set furnishing power to the 40" Reversing Blooming Mill motor of the Otis Steel Company, Cleveland, Ohio.**

and windage; the field losses and core or iron losses are very much smaller than normal. In low-speed machines, like the reversing motors for mill drives, the $I^2R$ losses comprise usually a large per cent of the total; therefore, if we impose such an artificial load on the motor and take this "short circuit heat run," maintaining the rated current, the temperature rise should be not far off, but will be still lower than the guaranteed rise at normal load. After this the machine may be given an "open circuit heat run," i. e., it will be driven as a generator with full field on, but with armature circuit open; under these conditions the field and core losses will produce a certain heating. It is then necessary to combine in a certain proportion the results of both heat runs and to estimate in this manner the actual temperature rise which would be obtained with a conventional heat run if such were feasible. Similar methods are in a very wide use for testing large A.C. generators and like.

**Conclusion**

I have been once reproached at a meeting of this Association for an alleged wish to substitute theoretical calculations for experience and intuition of operating men. Far from wishing to underrate the importance of the tremendous work done in this field by practical operating men—may I ask why their experiences should not be expressed and recorded in facts and, when possible, in cold figures? Are the results of tests carried in the mills, are the records obtained through years of operation not a part of the same engineering experience? Calculations based on this accumulated wealth of information is but a direct and organized means to make the best out of this knowledge; what may be more fitting to the very purpose of this Association?

If the paper just presented has convinced you on only one point, namely, that the problem of selecting reversing drives lends itself to the constructive blending of logic and experience—then I feel satisfied of having done my bit.

# *Discussion: Electric Heat Committee Report For 1925*

**Geo. H. Schaeffer***: In reference to the paper this morning, I want to say a few words as introductory. The Committee has tried to cover the entire field of electric heating. This Committee was originally called the Electric Furnace Committee, however, owing to the fact that there has been a great growth along the other lines of electric heat it was seen fit to change the name to Electric Heating Committee.

The attitude we tried to keep in mind on the subject in its different phases was, that we considered it on the question of cost of the finished product. We all must recognize that in making a comparison as to the cost of fuel and cost of electricity, that is, first cost—the cost of electricity is not as low as that of fuel. But we must consider the increased efficiency which is gained by the use of electrical energy.

Within the last few weeks I read in one of the periodicals that the people who were conducting the electrical heating campaign were keeping something under their hat, and were proceeding along secret lines.

I take exception to that. If there is something that has not been given due publicity, it is due to the fact that electric heating is so new that some things may be tried out and not meet with success —so, why give publicity to a failure?

The statement as to the use of three voltages is rather novel. I would like to ask Mr. Seede whether they have actually built furnaces for operating on three voltages.

I would also like to know whether Mr. Watson is here—to tell us of the heating of the ingot top.

**D. M. Petty***: I think Mr. Seede's report of progress, in connection with his paper, is all that can be said. I was rather surprised to hear of the triple voltage.

The point of interest, to my mind, is the fact that it will increase the number of kilowatts we put

*Chairman Electric Heat Committee for 1925.

*Elec. Supt. Bethlehem Steel Co., South Bethlehem, Pa.

into our furnaces. I remember a few years ago a statement was made by a combination metallurgical and electrical engineer, who said, "The limitations of the electric furnace are purely in the hands of the electrical engineer, and one of the principal limitations is the amount of electrical energy that we can put in the furnace."

**J. H. Seede***: As far as Mr. Schaeffer's and Mr. Petty's questions, about the actual use of three voltages, I attempted to emphasize the fact that these are being considered—at least, they appear to be considered—from little questions that come up here and there.

A long time ago, in connection with a fifteen-ton furnace, we were asked something about the complexity and cost of the apparatus that would give us a control such as was used on the big resistance furnace, and I am sure that the reply we gave discouraged the inquirer sufficiently to keep him out of it for some time.

Of course, it does increase the complexity, and increases the cost; but, having built the transformer with a certain voltage range and brought out a certain number of leads, then the addition of one oil switch and three taps through the cover does not increase the cost of the transformer or equipment very much, or the complexity of it. There is an increase you cannot get away from, but it is not very much. The cost of it is largely up to the fellow who puts it in.

If somebody will only tell us what K.V.A. and what voltages they want, we will always produce it with a furnace.

**Geo. H. Schaeffer†**: Mr. Wilcox, of the Ajax Company, just came into the room and may answer some of the questions about that American brass developer of five hundred and forty cycles.

**Mr. Wilcox‡**: I am sorry I didn't hear what Mr. Seede had to say about it, because I don't know how much he has divulged already; but the installation was put in last fall, and has been turning out metal regularly—nickel-silver, from a one-hundred kilowatt unit.

The American Brass Company are now putting in two six-hundred kilowatt high frequency generators to operate twelve furnaces of the same sort as have been operated for these eight or nine months.

The advantages seem to be the obtaining of better metal and, of course, the elimination of electro-losses, which would occur with arc furnaces—the yellow scoring of the metal, due to the electro-magnetic forces set up in the bath—and, we hope, a smaller power consumption per ton; but that latter will be better settled after the operation of the larger units.

If there are any questions, I would be glad to answer them as well as I can.

**W. P. Chandler Jr.§**: How many pounds are you melting in those furnaces now?

**Mr. Wilcox:** The charge is six hundred and thirty-six pounds, and the total bath is seven hundred thirty-six pounds; and we leave a certain amount in the bottom to help induction in the next melt. It is not necessary to have that small charge, because the furnace can be started right up with a broken mass of material in a new bath, so a different kind of mix can be made at each melting.

**F. W. Cramer***: Is the power consumption increased or decreased as the charge is melting?

**Mr. Wilcox:** The power consumption stays about constant.

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**Geo. H. Schaeffer:** If there are no further questions, I would like to ask Mr. Watson, of the International Nickel Company, to tell us about his experiments on heating the ingot top. I see Mr. Watson has just come in, and I would like to take this advantage. Will Mr. Watson, please come up here and tell us about it?

**F. C. Watson†**: I presume you have reference to the what we would call "heating the hot-top of the ingot?"

**Geo. H. Schaeffer:** Yes, sir.

**F. C. Watson:** I know our ingots are cast a little different from ordinary steel work. We cast the ingot with the large end up instead of down. It has been necessary in the past to cast the ingot with a long head in order to take care of the pipe, the head weighing on an average of eight hundred pounds for a small ingot, thirteen by thirteen. The ingot weighing about four thousand pounds after the head is cut off. Of course, it is quite an expense to saw the heads off. We have to remelt the heads and the handling of the heads made it rather expensive; so, we conceived the idea of using a single-phase arc on the head to keep the metal hot while cooling, to prevent shrinkage.

A small portable panel was built up using a standard single phase electric furnace regulator for controlling the electrode motor. On the panel was mounted the contact making ammeter, indicating ammeter and reversing contactors. The main current busses were run in a compartment along the side of pouring pit.

Of course, our production is very small compared to the steel production, because about four million pounds of ingots a month is as much as we can make. We use an electrode of about three-inch diameter. The electrode is placed over the ingot, the arc started and allowed to run for about two minutes at two to three thousand amperes. Then we taper off to between five hundred or a thousand amperes for a period of about three minutes, making a total of about five minutes.

In this way we get an ingot with a solid top. We do not have to saw off the top of the ingot. There are no pipes or anything of that kind. The length of time we keep the arc on the ingot depends somewhat on the length of time required to pour the metal. The hotter the metal when poured, the longer we wait before starting the arc.

The operation is very simple—there is nothing complicated about it. We worked up the truck our-

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*Engr. General Electric Co., Schenectady, N. Y.
†Elec. Engr., Carpenter Steel Co., Reading, Pa.
‡Sales Manager Northrop Company.
§Special Engr., Carnegie Steel Co., Pittsburgh, Pa.

*Asst. Elec. Supt. Bethlehem Steel Co., Johnstown, Pa.
†Elec. Supt. International Nickel Co., Huntington, W. Va.

selves. The standard parts were purchased and mounted on the small truck with a small electrically operated electrode winch. We have provided both automatic and hand operation. One electrician is present to look after the electrical equipment in case of failure, but all other work is handled by the refinery forces.

**W. P. Chandler:** How do you make your bottom contact?

**F. C. Watson:** The ingot molds are set on 100 lb. steel rails in the pouring pit.

**W. P. Chandler:** They are not on trucks—that is, the ingot mold itself?

**F. C. Watson:** No, we set the mold in a pit.

**W. P. Chandler:** Is the bottom of the ingot mold solid or open?

**F. C. Watson:** Solid, being a separate casting with machined face.

**W. P. Chandler:** Do you have trouble with the ingot sticking in the mold? Does it have a tendency to "freeze in" down where the current passes?

**F. C. Watson:** No, we have not had any trouble of freezing due to flow of current. Before any metal is poured a short refractory lined head is placed on the top of the regular mold. When the pouring is finished there will be 6 or 7 inches of hot metal in the short head. The arc is directed on this 6 or 7 inches of metal. Of course, there is some shrinkage to that, and when you take the top off there is about 3 or 4 inches extension of the ingot, which is taken into the hammer shop and put under the hammer without having to saw off any of the head.

**W. P. Chandler:** How many ingots?

**F. C. Watson:** That varies. With a three-ton electric furnace you would have only about four ingots per heat with one large furnace about eight and sometimes the open hearths come out at the same time as the electric furnace and we have a pit full of ingots. We have to regulate this as we have only six trucks, but as they are in service on each ingot only about four to five minutes, we can shift them around pretty rapidly.

We have figured on installing a timing device, or a timing relay, which would be automatic and as soon as the time was up it would cause the electrode to be drawn out of the bath.

We use a standard furnace type transformer, three phase, which we bought as a duplicate of one of our furnace transformers, our idea being to use it as a spare. However, I suppose, a single phase transformer could be used satisfactorily.

**A. C. Cummins***: Do you make some attempt at balancing your load?

**F. C. Watson:** Yes, by our system of bus connection. Our floor receptacles are so arranged that adjacent receptacles are on different phases.

**A. C. Cummins:** What voltage do you use?

**F. C. Watson:** One hundred volts. We have tried from fifty-nine volts to 110 volts, but the ninety to one hundred volts seem more satisfactory.

**A. C. Cummins:** Full load voltage?

**F. C. Watson:** Yes.

*Elec. Supt. Carnegie Steel Co., Duquesne, Pa.

**A. C. Cummins:** Otherwise you would have to saw off the heads of all your ingots, wouldn't you?

**F. C. Watson:** Yes.

**A. C. Cummins:** All the ingot heads?

**F. C. Watson:** Yes.

**H. C. Siebert***: What is your electrode—carbon?

**F. C. Watson:** Carbon. We have not paid any special attention to this feature. We used to have a small experimental furnace and had quite a number of 3" carbon electrodes on hand, so we designed our apparatus to hold that size of carbon. The electrode clamp is of ¼" x 3" or 4" copper bus. It is in service such a very short time that we experience no trouble from heating.

**W. J. Harper†**: Do you continue to use your refractory lined hot top with this equipment?

**F. C. Watson:** Yes, but it is much shorter than we used to use. We do this to keep the arc from spalling off the top edge of the mold.

**James Farrington‡**: I understand you to say you don't destroy your refractory hot top—you use it over again?

**F. C. Watson:** Yes. They are only about ten inches high. You can use them until lining is burned up or broken. As soon as the ingot is poured a cover, made of a refractory material and having a hole in the center large enough for the electrode to pass through is placed on the top of the mold. The cover helps to retain the heat and hold in the gases.

**James Farrington:** Is it on only two minutes?

**F. C. Watson:** It is on for about four or five minutes, depending on the temperature of the metal when poured. We have experimented with it anywhere from four up to twenty minutes.

**R. S. Shoemaker§**: How long a time elapses after the metal is poured before it is finished?

**F. C. Watson:** From five to seven minutes. We wait a while after ingot is poured before starting the arc.

**H. C. Siebert:** You seem to have eliminated the piping altogether, or partially.

**F. C. Watson:** Altogether.

**R. S. Shoemaker:** Do you find any difference in the quality of the metal where the arc has been used?

**F. C. Watson:** No, sir. We are very particular about this. The Metallurgical Department is very fussy about those things, and we watch it very closely.

When we first started this process we had some difficulty with short pipes, and the metal had a tendency to be a little spongy; but it was a question of studying the operation and of having a man there to see they did it properly each time.

To the ordinary workman in the refinery, a minute or two don't make much difference. We found by experimenting that when we got an ingot right

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†Steam Engr. Donner Steel Co., Buffalo, N. Y.
‡Elec. Supt. Wheeling Steel Co., Steubenville, Ohio.
§Supt. of Maintenance American Rolling Mills, Middletown, Ohio.

and kept the data on it—there was no trouble in repeating the operation.

**Thomas Hughes***: Does this plant operate for both Monel Metal and other kinds?

**F. C. Watson:** Yes.

**Thomas Hughes:** You do use carbon and does it affect the metal.

**F. C. Watson:** Yes, we use carbon. Our idea is to make the time as short as possible; so we do not have any trouble from carbon. We are trying a truck with two electrodes, but the single electrode has been satisfactory.

**J. D. Scully†:** Do you saw off the hot top?

**F. C. Watson:** No.

**J. D. Scully:** That is cut later, the same as the other?

**F. C. Watson:** Yes, any bad portion may be cut off at the hammer.

**E. S. Jefferies‡:** Would direct current be satisfactory, as well as alternating?

**F. C. Watson:** I don't know whether it would be or not. We have never tried it. Our is all alternating current.

**E. S. Jefferies:** How long after the ingot is poured before it is stripped?

**F. C. Watson:** I could not answer that definitely. I should say one hour to one hour and thirty minutes.

**Geo. H. Schaeffer:** You use this on finer steel or only on Monel Metal?

**F. C. Watson:** We do not make anything but Nickel and Monel Ingots

**Geo. H. Schaeffer:** But you have never tried it on any ordinary steel?

**F. C. Watson:** We do not make such metal.

**Geo. H. Schaeffer:** No reason to think it would not be effective?

**F. C. Watson:** I see no reason why it would not be effective.

**A. R. Leavitt§:** You say about three thousand amperes at one hundred volts?

**F. C. Watson:** We start with from two to three thousand amperes, for about two minutes.

**A. R. Leavitt:** And about a maximum of one hundred volts?

**F. C. Watson:** Yes, sir. And then we taper the current down just enough to hold the arc.

**H. C. Siebert:** What is this cap over the top, you speak of—cap over the ingot?

**F. C. Watson:** It is made up on the floor nearby.

**H. C. Siebert:** Out of some metal?

**F. C. Watson:** No, the cap is made from pieces of refractory placed in an angle iron frame. The cap is used to hold the heat and gases.

**W. P. Chandler:** You have a hole in it?

**F. C. Watson:** Yes, in the center of the cap just big enough for the electrode to go through.

**W. P. Chandler:** The piping rejection, that is, without this electrically heated hot top, would be about twenty per cent?

**F. C. Watson:** Yes.

**W. P. Chandler:** How much with this hot top ordinarily, what is the range of your heats?

**F. C. Watson:** Right now I think we are getting about eighty-five per cent, of our ingots that we do not have to saw and when we have to saw off a head the scrap is only about 200 lbs.

**W. S. Hall***: Eighty-five per cent of the ingots you do not have to saw at all?

**F. C. Watson:** Yes, after more experience with the equipment and it is given the proper attention each time, we probably will not have to saw any.

But, as I have said, we use the men regularly assigned to refinery work, and have one man, who is general maintenance electrician in the refinery department, present to see that the electrical equipment is all right. After the ingots are poured there cannot be any delay. If there is anything wrong with the truck or electrical apparatus it is necessary to get another promptly as the ingot does not stay hot very long.

**W. S. Hall:** What is your large ingot—you say thirteen by thirteen?

**F. C. Watson:** That is the large one—about sixty inches long, and it weighs about four thousand pounds without the head. We cast larger ingots—nickel ingots for special rolling, but our standard is thirteen by thirteen.

**A. J. Standing†:** For how long a period after you pour do you apply your heat?

**F. C. Watson:** That depends on the heat of the metal when it is poured. They wait a short period of time, maybe two or three minutes, before they put the arc on—to give the metal a little time to settle down.

**A. J. Standing:** The top of your mold is built up?

**F. C. Watson:** Yes, we have a hot top we set right on the mold just before the metal is poured. We used to put on a top that was eighteen to twenty inches high.

**A. J. Standing:** And as soon as that solidifies you lift the top off?

**F. C. Watson:** No, we leave it on until ready to strip the ingot. We pour about six or seven inches of metal above the top of the mold, and put the arc in, with the cover or cap on. Then, when it settles down, we have three inches of solid metal above the ingot—it tapers off, of course.

**H. C. Siebert:** What is the section of that three inches? Is that the same shape as the ingot?

**F. C. Watson:** About 11 inches across the top so you can lift the hot top right off.

**H. C. Sibert:** Is it the same shape as the ingot?

**F. C. Watson:** Yes, being about 11″ x 11″ on top while ingot proper is 13″ x 13″.

*Elec. Dept., Carnegie Steel Co., Duquesne, Pa.
†Asst. Elec. Supt., National Tube Co., McKeesport, Pa.
‡Elec. Engr. Steel Co. of Canada, Hamilton, Ont.
§Asst. Elec. Engr. Carnegie Steel Co., Duquesne, Pa.

*Elec. Engr. Illinois Steel Co., So. Chicago, Ill.
†Elec. Supt. Bethlehem Steel Co., Bethlehem, Pa.

**A. C. Cummins:** How much taper do you have in the ingot itself?

**F. C. Watson:** I think it is about an inch in five feet. I can not answer the question why we pour our ingots that way—it is for a metallurgical reason. I have not been able to get any very definite reason why it should not be poured any other way. They have for years poured it this way.

**A. C. Cummins:** What size electrode do you use?

**F. C. Watson:** About three inches. We did not figure on any particular size. We use the three-inch electrode because we had a quantity of them on hand, but they have proved satisfactory.

**A. R. Leavitt:** You use graphite electrode?

**F. C. Watson:** No, a carbon electrode—the company had some carbons shipped down from the old plant and we are using them up. I suppose if we went out now to buy a new stock we would buy the same size as long as it is satisfactory.

**A. R. Leavitt:** Do you use cables connected to the electric furnace transformers or furnace feeders?

**F. C. Watson:** No, we have a separate transformer.

**C. S. Proudfoot*:** Where do you take the power from?

**F. C. Watson:** We are taking this off the circuit of one of the electric furnaces, and I have never had any complaints that it interfered with the operation of the electric furnace. We did not have a separate circuit available. You can see it is not much of a load.

**C. S. Proudfoot:** What is the kw. consumption for that period of time?

**F. C. Watson:** I never figured it out very closely, but you can see that two or three thousand amperes for 2 minutes—and eight hundred for three minutes—would not amout to very much, approximately 10 k.w. hrs.

We had to develop a connector that would carry the amount of current and yet be small, as we had to make a connector that would also carry the contacts for the control circuit. We were unable to find anybody manufacturing a plug and receptacle that would carry two or three thousand amperes.

A bus trench runs on each side of the pouring pit and in each trench is a 3-phase circuit made of ¼" x 4" bus copper mounted on standard bus insulators.

**Geo. H. Schaeffer:** Mr. Watson, I am not clear on some of this. Was your statement to the effect that you use bottom pouring?

**F. C. Watson:** No, we pour from the top.

**Geo. H. Schaeffer:** And as to the four inches—do you pour it about four inches in the hot top?

**F. C. Watson:** Yes, sir.

**Geo. H. Schaeffer:** As to the temperature, I suppose you use optical pyrometers?

**F. C. Watson:** Yes.

**Geo. H. Schaeffer:** For each ingot?

**F. C. Watson:** No. We do occasionally, but they always know the temperature of the metal coming out of the furnace.

**Geo. H. Schaeffer:** Then, you do not treat each ingot before and after the application of the electrode?

**F. C. Watson:** No.

**Geo. H. Schaeffer:** About what is your pouring temperature?

**F. C. Watson:** It varies—it is around about twenty-eight hundred degrees, sometimes a little higher than that and sometimes not quite so high. The higher it is the longer we wait before putting on the arc.

**Geo. H. Schaeffer:** What is the composition of your bowl?

**F. C. Watson:** Cast iron.

**Geo. H. Schaeffer:** What is the object of waiting?

**F. C. Watson:** We try to have the metal in the mold about the same temperature each time, as near as we can get it. This gives the metal a chance to quiet down after pouring. If you tell the men to put on the arc and leave it on four minutes and a half or five minutes they know just what to do, but if we were to vary the time on each heat somebody would have to be there to determine the time. The man in charge will not let them start until he thinks the metal is about right. We run this operation during the night as well as the day and get about the same results, probably slightly better results in the day.

**Geo. H. Schaeffer:** You say you use a solid mold? Solid on the bottom?

**F. C. Watson:** Yes. We use a mold base, putting the base down and setting the mold on top of the base with asbestos joint between base and mold. The base sets on two one hundred-pound rails. We have a great deal of trouble with the rails warping. I think some kind of a heavy casting to set the base on would give less trouble.

**Geo. H. Schaeffer:** Do you have any trouble with stickers?

**F. C. Watson:** Yes, we have stickers—always did have them; and have them yet.

**Geo. H. Schaeffer:** Isn't that base cast, too?

**F. C. Watson:** Yes.

**Geo. H. Schaeffer:** You have quite a large contact in your ingot?

**F. C. Watson:** Yes—I think the smallest ingot is about 11 inches square at the bottom.

**Geo. H. Schaeffer:** Is the cross section of your mold pretty heavy? Or light?

**F. C. Watson:** It does not need to be for carrying the current as the current is carried through the ingot and not the mold. I do not think we have anything special about our molds.

**Geo. H. Schaeffer:** Is the mold the same from top to bottom, as to thickness?

**F. C. Watson:** No, there is a taper to it.

**Geo. H. Schaeffer:** The metal itself?

**F. C. Watson:** The wall is thicker at the bottom than at the top—practically straight on the outside.

**Geo. H. Schaeffer:** Practically straight?

**F. C. Watson:** Yes. The small end of the ingot is down.

*Genl. Mgr. U. S. Ferro-Alloys Corp., Niagara Falls, N. Y.

**Geo. H. Schaeffer:** The tendency is to chill the ingot on the bottom, is it?

**F. C. Watson:** Yes, sir. It starts cooling from the bottom.

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**H. C. Siebert:** Like the rest of you boys, I am very glad to be on hand, even though I came late, very late. I am glad to have had the good fortune of hearing these papers on this very interesting subject. Most of you are now aware of the fact that one of the great factors in the production of these materials is the heating furnace, and like those other engineers I am vitally interested in anything that will reduce the cost.

In that connection I have in mind the remarks Mr. Hurme and others have made, that we should not make a direct comparison of the one with the other from the standpoint of fuel alone, for in connection with the electric pit there are so many other items involved—one being the improved quality of the material.

The fact I have in mind, however, is that with the present cost of generating electric current as against the present cost of other fuel, even assuming that the electric furnace will operate with extremely high efficiency as compared with other furnaces, the cost of heating is rather unfavorable to the electric furnace. There have not been any definite figures presented on that point; and if anyone has figures in that connection, I would be glad to receive the same.

Several years ago I had occasion to compare an electric furnace, which heats rivet steel, round steel bars sixteen feet long, grips it in an electrode and passes current through—a comparison of that with an oil-fired furnace was surprising to me, even assuming an efficiency of the electric furnace at eighty-five per cent, and assuming kilowatts at eighteen per hour (?)—at sixteen cents per gallon for oil it showed that the cost of the electrically heated furnace was greater—the cost of current was greater. I realize that our present oil or gas or coal fired furnaces can be improved very materially. In many cases their efficiency can be practically doubled.

I also recognize the great advantage that the electric furnace has—and that advantage is, the getting away from the human element. The more we get away from the human element or, the more we eliminate the human factor in the control of any apparatus the better off we are.

That is a point I wish to stress. I have pretty firmly fixed in my mind that with our present cost of generating current it doesn't seem to be very favorable in competition with the gas or oil fired furnace.

**T. F. Bailey***: As to cost, I think the figure of eighty kilowatt hours per gross of ingots is a very fair figure to take on the operation of this small electric pit.

Answering your question, Mr. Hurme, bear in mind that the electric soaking pit performs an operation on hot ingots, not on cold ingots—because, in cold ingot heating we run into a different character of cost than we do in soaking pits, where the ingots come hot. In one or two cases, in this country more particularly, the heating of the exterior of the ingot is done by the hot interior—they are allowed to soak and adjust themselves; and in that field is where the electric soaking pit is bound to come.

**E. A. Hurme***: They are heated to twenty-two hundred degrees?

**T. F. Bailey:** Sixteen hundred and sixty degrees to about twenty-two hundred degrees—that is, the interior of the ingot will be around twenty-four hundred or twenty-five hundred degrees. The actual heat required will probably not—if transposed into kilowatt hours—will not exceed probably forty-five kilowatts.

**E. A. Hurme:** You haven't expressed that in terms of per cent of heat, have you, or per cent of efficiency?

**T. F. Bailey:** The Donner pit is about fifty per cent.

**E. A. Hurme:** Fifty per cent thermal efficiency is certainly very high.

**T. F. Bailey:** Not in electric pits—not in electric furnaces.

**E. A. Hurme:** I am very glad to hear that we are on the road to very high efficiencies in pits. I think all steel mill engineers are willing to admit that our present pits have very low efficiency; but to jump from that low efficiency to fifty per cent efficiency on hot steel is, I think, very good work.

**T. F. Bailey:** On electric pits?

**E. A. Hurme:** Any kind of pit. I don't care what the source of heat.

**T. F. Bailey:** I might say here that electric operation will show a better thermal efficiency relatively than fuel firing, the higher the temperature to which the steel is heated, just as you get better thermal efficiency from an electric melting furnace than in the open hearth. You have not the factor of combustion efficiency to take into consideration, and no stack losses.

**E. A. Hurme:** But the flow of heat is dependent upon temperature differences, you cannot get away from that. The flow of heat must be from the hot body to the cold body.

**T. F. Bailey:** Surely.

**E. A. Hurme:** Therefore, the hotter the ingot going in, the less that differential.

**T. F. Bailey:** That is true.

**E. A. Hurme:** But I was glad to hear that just the same.

**T. F. Bailey:** In the ordinary calculation, in the design of furnaces, we figure, for instance, the actual outside dimensions the pit must be, and calculate the wall loss in Btu. or kwh., and then add to that enough heat, kwh. to do the work. In all electric operations, except, perhaps, in refining electric furnaces, very high thermal efficiency will be shown. In some heat treating furnaces you get above eighty per cent efficiency. Such furnaces have been running for eleven years for the National Malleable Casting Company, at a temperature of sixteen hundred and sixty degrees.

I think it might be well to re-state one section of the committee's report—in reference to the comparison between electrical energy and any other form of energy.

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*Pres. Bailey Furnace Co., Cleveland, Ohio.

*Mgr. Steel Mill Div. Westinghouse Elec. & Mfg. Co.,

It was our idea to make the point clear that electrical energy seldom could compete with any other kind of fuel solely from the standpoint of first cost, but the comparison should be made of the cost of the finished product, so as to ascertain the advantage of electric heat as well as the cost of electric heat.

In reference to the rivet machine, I don't know just what the relative costs are, other than Mr. Siebert has stated, but if you add the operating improvements, or, better operating conditions obtained from an electric heating rivet machine, as compared with a gas fired machine, I feel as though the overall cost would be less because of the elimination of the gases and the destruction of the building, et cetera.

**W. P. Chandler:** Gentlemen, two combustion engineers following one after the other, with discussions of an electrical paper, looks a little peculiar; but the answer is that electricity is a fuel. As a source of heat, electricity is rather expensive at the present time, and, in comparison with other sources, it is almost out of the question; but in treating steel, where the character of the material being heated is of prime importance—and the soaking pit is one of those in point—I believe the electrical soaking pit has a future, the developments of which will probably be brought about by demand. Electricity and gas, in point of cost, are very, very far apart. At present it will cost anywhere from ten to twenty cents per ton to run a soaking pit on gas, and with Mr. Baily's figure of eighty kilowatt hours per ton the cost would be eighty cents per ton, approximately. This is a difference of sixty cents per ton, which is a good deal. But, at the same time, there is a lot of steel ruined in the soaking pit in operation—perhaps because the heater becomes careless or the automatic controls fall down or something goes wrong with the general scheme of things; and the answer is probably a high chipping cost down in the billet yard. If that can be reduced, if we can heat steel in an electric pit and it will give us a lowered chipping cost, the discrepancy in fuel cost can be easily overcome. But the main thing that remains now to be proven is, what that reduction in actual chipping cost is going to be or what proportion of the steel is going to be free from that cost; and the only way we can get that is by the Donner Steel Company, or some other installation, going ahead and experimenting—a pioneer in the field—and determining whether it is actually a paying proposition—because the dollars and cents end of it is going to tell in the end.

**Mr. Knape:** I am glad to see the attitude the committee has adopted toward the electric furnace—that each one should be considered on its merits. The electrical manufacturer must recognize the fact that the electric furnace is not a low cost fuel consumer. All things being equal, it costs more to operate an electric furnace. The question is, what thing can be capitalized in the electric furnace. In some installations this question is very easily answered. In the heat treating of link gears in the electric furnace it was found the saving in subsequent operations—sand blasting and scraping—was several times the cost. The question was considered in reference to brass, the saving in breakage and the cleaning of brass, and these were at the same rate. In annealing glass it was found that a similar saving was made

Such features are tangible and can be put on a dollars and cents basis. There are, however, certain intangible features, which should be taken into consideration. I want to make a particular plea for one feature of electric furnace heating, and that is the question of improved working conditions. Practically all large manufacturers have welfare departments for the improvement of the men—safety devices, have installed up-to-date lighting systems, have painted the inside of their buildings white, and so forth. Therefore, it seems logical that a certain amount of money should be spent in the furnace room to keep the temperature down, to do away with gases and fumes, which are not only disagreeable, but may be injurious, and do away with the noise of oil burners. In many cases these things are intangible and cannot be capitalized; in other cases they can be capitalized. One manufacturer reported his labor turnover was very materially reduced after the installation of the electric furnace.. One large automobile manufacturer, in one of his heat treating rooms, installed electric furnaces, and he made a very careful analysis of the conditions in his new and his old gas fired room. The gasses and air of the two rooms were analyzed and a record kept of the quantity of work done. On the basis of one hundred per cent of work turned out in the electric furnace room it was found that only seventy-five per cent of this quantity was turned out in the gas furnace room.

I am firmly convinced this is a feature, which will bear added weight in the future.

**Geo. H. Schaeffer:** Mr. Hurme took up the question of heating tin plate. I understand Mr. Hunter is here, and I would like to know whether he has anything to add on that subject.

**John Hunter*:** Just in what way do you have in mind?

**Geo. H. Schaeffer:** Well, just what do you think of the electrical application?

**John Hunter:** We have tried electrical application to heating tin plate, and have experimented a good while and have not been able to make it go. I think Mr. Bailey knows more about the details of that than I do—he has kept more closely in touch with it We haven't done anything since that time, but I question whether at this time, economically, it could be justified—that is, from the standpoint of fuel saving. In other things—maybe special kinds of steel for special purposes, it may be that electrical heating might be justified. As mentioned in the paper, I think Mr. Hurme said there are special steels that have to be normalized—and there you might be able to make the application; but we haven't made any application as yet. But for general tonnage and the ordinary run of steel, I don't believe it can, as yet, be justified.

**Geo. H. Schaeffer:** We don't expect that we are going to win out on every application. Every source of energy, every test, will help us along; and we must naturally expect that there will be some cases

*Chief Bureau Steam and Sanitary Engr., American Sheet and Tin Plate Co., Pittsburgh, Pa.

where electricity cannot compete with some other kinds of fuel.

**T. F. Bailey:** About the tin plate application, I am somewhat interested. The units in that were installed outside of the pot—our idea being a closer control of temperature, keeping the tin from oxidizing in the oil.

Contrary to expectations we found the same trouble as obtained in fuel-fired pit—tremendous temperature outside of the pot. When production stopped this tremendous temperature of the tin in some cases fired the oil.

We are now to use an emergent unit inside the tin, so the tin will rise to higher value, but directly relieving us from the danger of these extremely high temperatures. The efficiency should be much higher. So, with this new lineup we should obtain the results intended—that is, not oxidizing the tin and not firing the oil.

**James Farrington:** What did you say was the thermal efficiency?

**T. F. Bailey:** The thermal efficiency, I should say, is at least eighty per cent. The unit we placed inside the tin and outside the pot—it was very well insulated.

**Geo. H. Schaeffer:** There are many factors that go into the cost of the finished product. We all know our customers are getting more critical, and I have talked to several men on the sheet and tin plate subject, and it is their opinion that sheets would have to be treated separately, and the quality that was demanded would have to be made in the electric furnace regardless of the cost. So it is not always a question of whether we are going to do it cheaper by electricity, but sometimes it is a question whether we can get the results any other way than by electrical methods.

Are there any other questions?

**James Farrington:** I would like to ask Mr. Bailey if they have designed a six-ingot pit, and if so, the approximate cost of same.

**T. F. Bailey:** You mean six-ingot pit or four-hole pit? We had a standard four-hole pit, and such installations cost about eight thousand dolars to compete with electric equipment, except the foundation. The space required would be about half that of a gorge pit, and the foundation would cost about one-fortieth. Eighty thousand dollars covers all the materials entering into it.

**James Farrington:** Have you an order for one?

**T. F. Bailey:** Unfortunately, we haven't an order for such. We are trying to get one. In regard to the sheet annealing, it may be interesting—following out Mr. Schaeffer's suggestion, I have been in fourteen or fifteen of the plants within the last six months, on sheets. A full yield of prime sheets generally does not run over seventy per cent; we consider we have very good results at eighty per cent. I don't believe anybody is claiming a ninety per cent yield of prime sheets.

If electrical energy will do it at four or five or six hundred kilowatt hours, at one cent and a half, the operation is bound to be an electrical operation. There is bound to be scaling or pitting on all annealing sheets, and it is an important question in the industry now.

**Mr. Carr:** I think Mr. Bailey brought out a point that should be recognized. We cannot expect electric heating to compete with gas or coal or oil on a fuel cost basis or on process of work, but on finished material you get the advantage. There is an application for electric heating almost regardless of cost, because of the saving of rejections; and, in many instances, the saving of waste labor will save the cost of the furnace in a short time; so that it would be a paying proposition to use electric heating even if the cost of electricity would be ten times that of the oil or gas. The automotive industry is a good example. About a year and a half ago there was put into operation at the Lincoln plant, of the Ford Motor Company, a furnace for annealing the components of the Lincoln engine. They experienced a twenty-five per cent reduction in cost of production, on the basis of individual box type, oil-fired furnaces at a minimum Btu. basis. The labor cost of this new furnace has reduced seventy-five per cent of the rejections. The saving on rejections alone has paid for the furnace, and the reduction in labor cost has paid for the cost of operation.

At the Hudson-Essex plant within the last three years they have put in between sixty and seventy-five thousand dollars worth of electric heat treating furnaces in place of coal equipment. They have practically nothing on rejections, and have effected a saving in labor which has paid for the furnaces.

At the Dodge plant, one of the biggest plants in the country, they have put in two large revolving, carborizing furnaces, for carborizing gear parts for the Dodge car. Each furnace costs approximately twenty-five thousand dollars. Each furnace requires two men to operate, and they will take the places of eighteen oil-fired furnaces, each of which took four men to operate. The cost of operating, on the Btu. basis, is slightly greater than the oil-fired furnaces, but the saving is about sufficient to pay for operating cost, beside the saving in labor.

Henry Ford, at the present time, is spending about one and a half million dollars on electric furnaces, replacing all his oil furnaces by electric equipment. Dodge, at the present time, has contracted for a hundred thousand dollars worth of electric furnaces.

One of the outstanding electric furnace companies in Detroit—I learned at the steel convention in Cleveland—has contracted for nine thousand kilowatt capacity electric furnaces. This is all for finished material. The same thing will apply in the sheet steel and sheet annealing. All that is required for annealing without scale is that it releases satisfactorily. But when you finish annealing, the best I have ever been able to do—and the very best oil-fired furnace practice, with the most skilled, highly trained and carefully observant operator, with the best system—has given a ten per cent rejection.

If an electric furnace will save eight per cent of that rejection, so that our total would be two per cent, it would pay for itself if it costs ten times the price of the oil-fired furnace. Take brass at eighteen cents a pound—down to about twenty gauge. The cost for every pound of brass is so great that a saving of from five to eight per cent in the final product—which is sold subject to close inspection and microscopic examination as to crystal size—will pay for the operating of the electric furnace.

# *Electrical Rolling Mills*

By D. W. BLAKESLEE*

IT IS universally admitted that the applications of electricity have made possible the scientific development of rolling mills to their present high state of perfection. It would now seem to be almost impossible to operate a rolling mill without electric motors, and, in fact, a mill with anything like modern high-speed production and efficiency could not be manipulated without electrical control.

### Finishing Mills

Under the general head of "finishing mills" may be grouped bar mills, rod mills, rail and structural

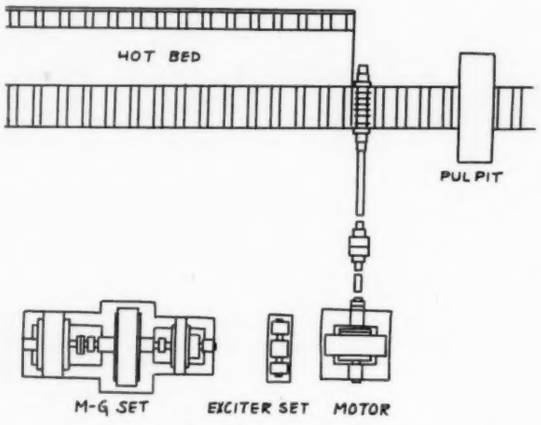


FIG. 1

mills. While these mills are named for the product for which they are especially designed some of them may be employed to roll one or more of the other products; their general arrangements are, however, usually very different. These arrangements or types are known as: single stand, three high; two high, reversing; combination three high and two high; continuous; looping.

### Bar Mills

Bar mills are of great importance because of the relatively high proportion of the total steel tonnage

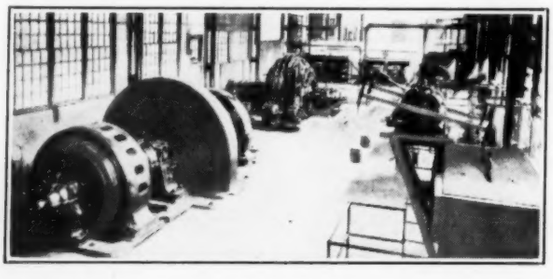

FIG. 2.

which passes through them. Their products are only semi-finished; the bars may be rectangular, round, flat, or special, depending upon the finished product for which they are intended. The so-called "tin Bar" may be included; it is a rectangular bar about 8 in wide and of thicknesses to give weights from 7 to 43 pounds to the lineal foot. It is finished for tin plate. Other bars are used for the manufacturer of nuts, bolts, rivets, automobile and machine parts, chains, and for structural work.

Flat bars run from 3/8 in. by 1/8 in. up to 6 in. by 4 in., and are used in the construction of machinery, buildings, automobiles, furniture, etc.

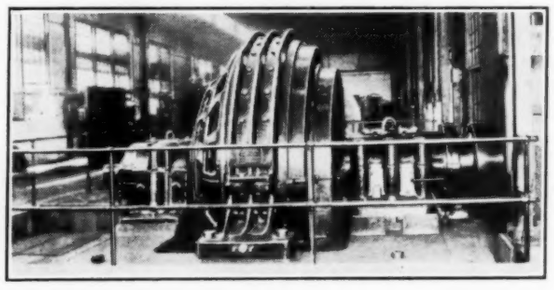

FIG. 3.

As its name indicates, the single stand, three high mill consists of three rolls in one vertical stand. These rolls are so grooved and spaced that the steel usually passes between the lower and middle roll in the first groove during the first pass, then in the second pass it comes back through the first groove, but between the middle and top roll. The metal is rolled starting at alternate ends with each pass; in

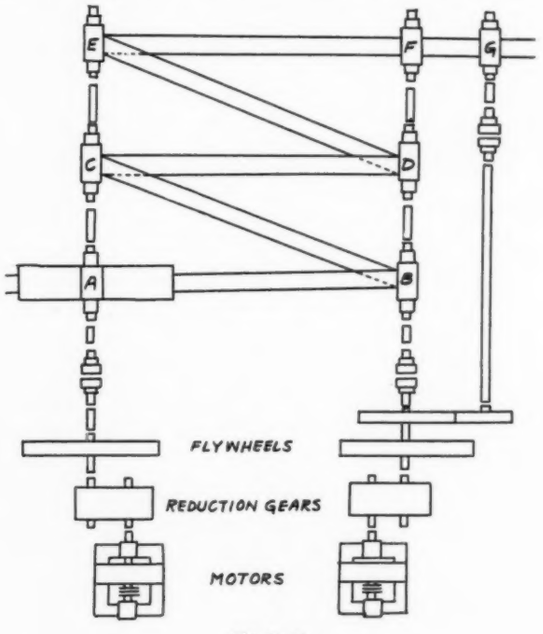


FIG. 4

other words, it always keeps the same relative direction with the axis of the rolls, and is not looped around from one pass to another. Next it is run through the second groove for two passes, as it was through the first groove, and so on through all the grooves (except, perhaps, the last), which are so

*Electrical Engineer, Jones & Laughlin Steel Corpn.

designed that the steel during the rolling is reduced in section and changed in shape so as to produce the desired bar. The metal usually passes through the mill an odd number of times so as to give a continuous flow of material through the works. The average number of grooves in each roll is seven, therefore the average number of passes in the one stand is thirteen. As the rolling is done at two elevations the metal must be raised and lowered between passes; this is done mechanically by tilting tables, and in the larger mills it is moved from

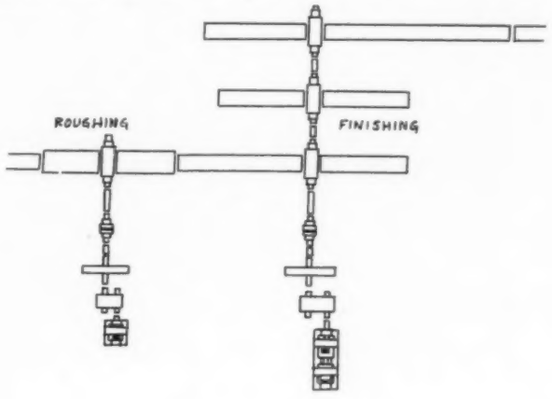


FIG. 5

groove to groove by manipulators, as in the three high bar mill of the United Alloy Steel Corporation which rolls ingots weighing 2,900 pounds from 14 in. by 16 in. down to ½ in. by 8 in. The advantage of the three high mill is that the motor need not be reversing as the rolls continue to rotate always in the same direction.

So that the rolls will not unduly drop off in speed as the steel enters the mill, a flywheel is usually provided to give up its stored energy upon a reduction of speed. As the motor must be relatively higher in speed than are the rolls (to permit of reasonable motor design), a reduction gear is required between the mill and the motor. The Canton Steel Company have a three high mill of this type which is driven by a 15 h-p. slip ring induction

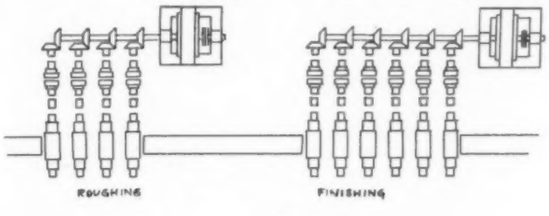


FIG. 6

motor having a speed of 234 r.p.m. It is controlled by a slip regulator.

The two high reversing mill is unusual as a bar mill, although the Follansbee Bros. Co. operate one in their sheet bar mill at Toronto, Ohio. Its use is justified by its extra fine quality of product which is used in the manufacture of fine automobile sheets. Fig. 1 shows a layout of this 30 in. mill with its rotating electrical equipment. It takes 6½ in. by 6½ in. blooms, which have been reduced by steam press from 11 in. by 11 in. ingots, and rolls them into bars 8 in. wide and 3/16 in. to 7/8 in. thick without reheating. The seventh pass delivers the sheet bar to the hot bed, from which it is conveyed to the shear where it is cut to size for the sheet mill.

Fig. 2 and Fig. 3 are from photographs of this mill's equipment, which has a continuous rating of 2,000 h-p., 0 to 100 r.p.m. In this type of mill a flywheel cannot be used on the motor as it must have little inertia to permit rapid change of direction of rotation from full speed in one direction to full speed in the other. To prevent heavy surges in the line to this type of mill, due to the fluctuating

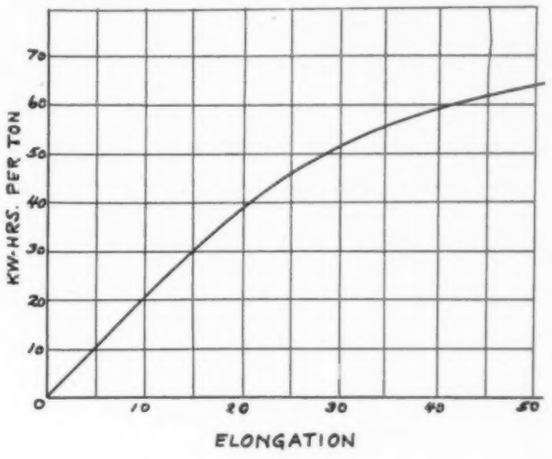


FIG. 7

demand of the motor, it is connected to a motor-generator set which is provided with a flywheel which stores up energy and gives it out as the motor requires less and more when it tends to have its speed increased and decreased, respectively, by its load.

A very common bar mill arrangement is the combination of two trains of three and two high stands

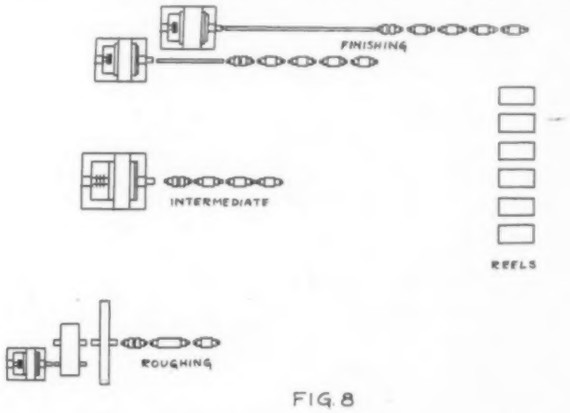


FIG. 8

as indicated by Fig. 4. Stand A is three high and has tilting tables; it is a roughing stand. From stand A the metal is conveyed by roller table to stand B, which is also three high; the steel first passes between the top and middle rolls from which pass it drops by gravity into position for the return pass between the middle and the bottom rolls; two passes are then made through stands C, D, and E, in the same manner as through stand B. The stands F and G are two high, stand F having a set of vertical rolls to true the edges, and stand G making the

finishing pass. This arrangement of a 21 in. mill requires two driving units of 3,500 h-p. A mill of this type having but two stands in each train would require two units of about 2,000 h-p. for an 18 in. mill.

A bar mill may have an arrangement as shown in Fig. 5, which is like the Belgian merchant mill,

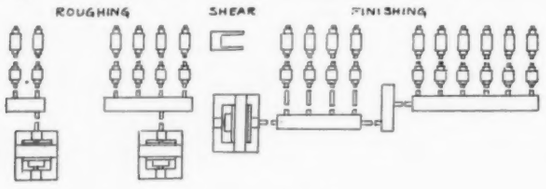


FIG. 9

and has tilting tables, transfers, and repeaters to handle the metal mechanically. Automobile steel is rolled in such a mill, with one more stand, by the Central Steel Co. The motor on the roughing train is about 850 h-p , at 500 r.p.m., for a 24 in. mill at 80 r.p.m. The driving unit of the 18 in. finishing train is about 2200 h-p., at 500 to 300 r.p.m., with mill speeds of 150 to 90 r.p.m Fig. 5 indicates re-

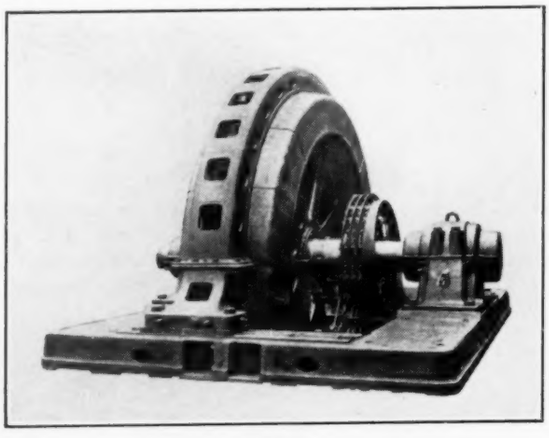

FIG. 10

duction gears and flywheels; the latter weigh 30 tons each.

Fig. 6 shows a layout of a continuous bar mill. The best arrangement is to have the roughing stands and the finishing stands in line with the blooming mill as indicated. The steel may be rolled through the blooming mill, roughing stands, and finishing stands, in one heating. As shown, one motor drives

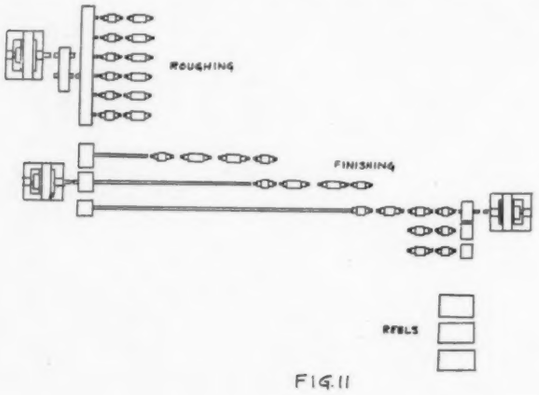


FIG. 11

each mill by means of beveled pinions and a common shaft coupled direct to the motor. Of course, the ratios of the pinions have to be such that the rolls will turn faster as the section of the metal being rolled is reduced. After the steel passes through the last finishing stand it is carried by roller tables to shears where it is cut to the required lengths. In this type of mill the motor is of low speed and no flywheel is required as the load is not so fluctuating since the steel is usually in all or many of the

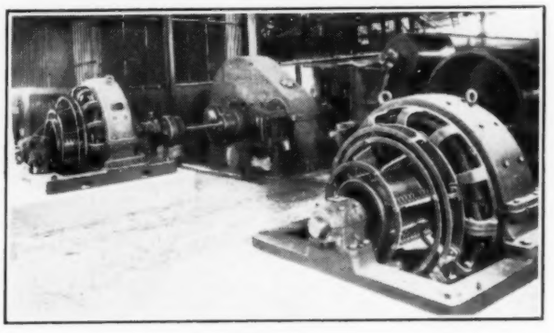

FIG. 12

stands most of the time. The United Alloy Steel Corporation have an 18 in. mill of this type with a 4200 h-p. motor rated at 93 r.p.m. The Weirton Steel Co. have a 93 r.p.m., 4000 h-p. motor driving a 21 in. mill, and another driving an 18 in. mill, of 4 and 6 stands, respectively.

Beside the main mill drive, there is much auxiliary equipment which may be best driven electrically, such as: tilting tables, manipulators, roller tables, transfer tables, shears, hot bed conveyors, and saws. The types of motors selected for these applications depend upon the sizes of the motors required and their applications. The motors connected to the

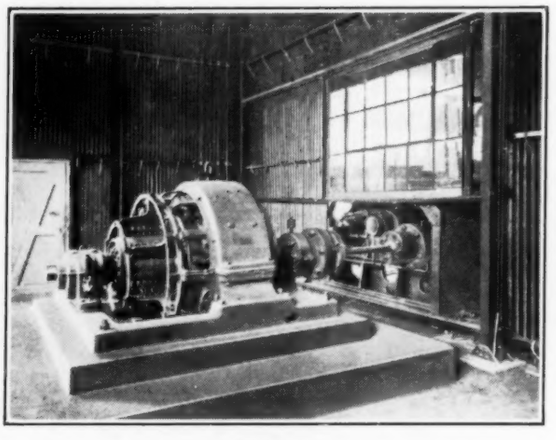

FIG. 13.

tables and manipulators should be of the standard mill type, but the smaller motors on the saws and shears may be squirrel cage induction motors. High resistance end rings might be used to advantage on the squirrel cage rotor of the motors on the smaller cold saws. The larger saws and shears may be better operated by wound rotor induction motors.

The amount of electrical energy required by a rolling mill depends upon a number of factors, the more important of which are type of mill, amount

of elongation of the metal, temperature of the metal, rate of operation in per cent of mill capacity. As a rough indication of the demand rate of the average mill Fig. 7 shows the relationship between kilowatt-hour per ton against elongation. It is believed that what few bar mills are still driven by steam, and all new mills to be built, will some day be motor driven,

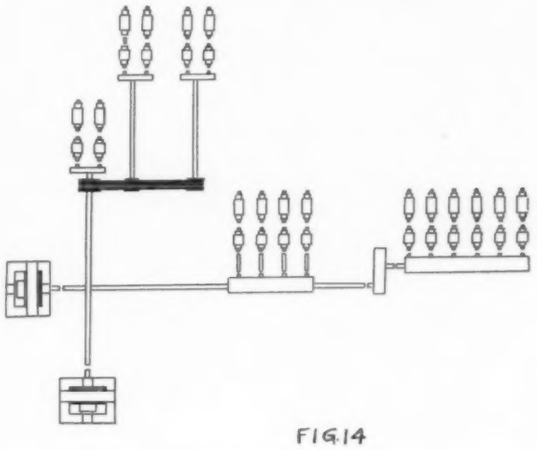

FIG.14

because of the high efficiency and greater tonnage to be obtained by electricity.

### Rod Mills

The rod mill, like the bar mill, usually turns out a semi-finished product. Wire rod is believed to be the bulk of the product. Some wire rod is rolled in merchant mills. In the beginning of rod rolling history in the country the rod mill was two high non-reversing, the metal being handed over the top roll for the next pass. Then a third roll was added at the top of the stand and the metal returned between it and the middle roll. When the metal became sufficiently elongated it was started between the top and middle roll before it was all through the middle

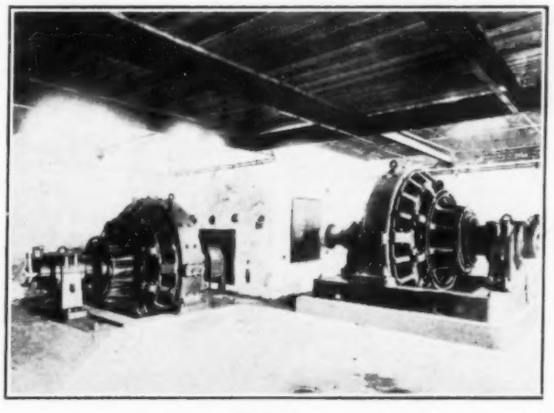

FIG. 15.

and bottom rolls, thus forming a loop. The next advances were to add one stand after another to the mill.

Fig. 8 shows a looping bar mill. The grooves in the rolls make the metal alternately square and oval. As the steel is given a quarter turn only before entering the rolls, which produce the oval shape, it is entered into the next stand mechanically thus reducing the number of men required to operate the mill and also speeding up the mill. This mechanical work is done by what is called a repeater which consists of a semi-circular guide, or trough, from which the loop springs as soon as it enters the rolls and so permits the required expansion of the loop. This type of mill usually starts with a 4 in. by 4 in. billet which is reduced to a number 5 rod, which is about

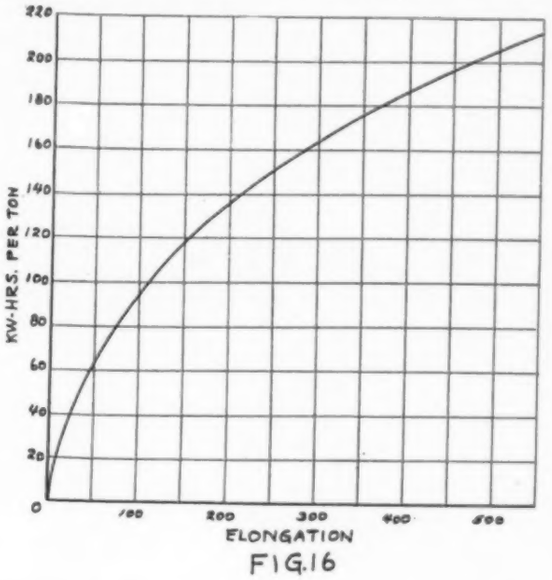


FIG.16

0.208 in. dia. Constant speed wound rotor motors are used for this type of mill.

To make unnecessary the employment of men to catch and enter the steel between passes, and more especially to go beyond the speed limitation imposed by the hand labor, the continuous mill was devel-

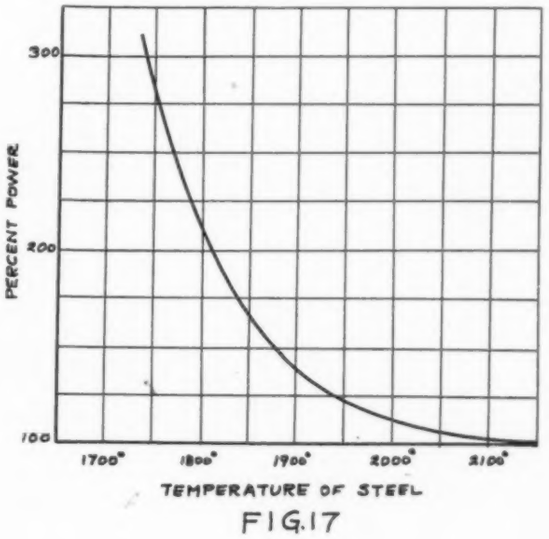


FIG.17

oped. This type of mill consists of series of stands in line so that the metal passes directly from one stand to the next, the stands being very close together. The stands are not much farther apart than the distance required by the guides employed to put a quarter turn twist in the steel between stands. The layout of a continuous rod mill is indicated in Fig. 9. This type of mill usually starts with a billet of 4 sq. in. in area and reduces it to a section of about

0.033 sq. in. The location of a flying shear is indicated between the roughing and finishing stands. The flying shear is a shear which moves with the metal while the cut is being made, and thus causes no looping between the shear and the rolls from which the steel has just come. Instead of the stands being driven by two or three motors as indicated they may be all driven by one motor. The American Steel and Wire Co. have a mill with all stands driven by an arrangement of gears to one motor similar to that shown for the roughing stands in Fig. 9.

In the continuous mill speed adjustment is of little value as the relative speeds of the rolls are fixed by their gearing. Therefore the induction motor may be used for this application. Fig. 10 shows the wound rotor motor on a mill of this type used by The American Steel & Wire Co., at Cleveland, which motor is rated at 2600 h-p.

The rod mill may be semi-continuous, which type is a combination of the continuous and looping types. Such a mill, as indicated in Fig. 11, is used by the Atlantic Steel Co., at Atlanta, Georgia. Adjustable speed motors are required for this type of mill, therefore direct current motors find their correct application here. Figs. 12 and 13 show such motors used in connection with the mill at Atlanta, they are 950 and 1850 h-p., and 975 h-p., respectively.

Another arrangement of semi-continuous type is shown in Fig. 14. This layout is used by the Steel Company of Canada. This arrangement is more flexible than the other, therefore the rolls need not always be changed with the product. Fig. 15 shows the two 1600 h-p. motors used with the Fig. 14 layout. The control is usually magnetic for starting and field control for speed adjustment.

There is quite a wide variation of the required energy for the different types of rod mills. A graph showing the average relationship between the rate of kw-hr. per ton to the elongation is shown in Fig. 16. The rate obtained may be more or less than that indicated for a given elongation depending upon the design of the sizes of metal, temperature of the steel, etc. Fig. 17 shows how the power consumption may vary with the temperature of the metal. Each design requires special consideration by an electrical engineer familiar with rolling mill applications.

# *Items of Interest*

The Baker R & L Company, Cleveland, O., has changed its corporate style to The Baker-Raulang Company. The company manufactures a complete line of electric industrial material-handling tractors and trucks, under the "Baker" name, and is also a quantity-producer of closed bodies for automobiles, under the name "Raulang." Both products have been widely and consistently advertised for many years and the name-change has been made to effect a close and unmistakable tie-up with the company's advertising.

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W. F. James has been appointed manager of the Philadelphia district of the Westinghouse Electric and Manufacturing Company, succeeding Mr. H. H. Seabrook, who has been assigned to special duties. Announcement of the changes was made by E. D. Kilburn, vice president and general sales manager of the Westinghouse Company.

Mr. James was born in Philadelphia in 1879. He received his early education in the Philadelphia public schools, graduating from the Central Manual Training High School in 1896. Upon graduation, he entered the employ of the Quaker City Electric Company and served his apprenticeship with that company. During this period of apprenticeship, Mr. James obtained his technical education by means of private study, which aided him greatly in later becoming electrical designer and then superintendent of the Quaker City Electric Company, which position he held for five years.

He resigned, in 1909, to join the Philadelphia sales office of the Westinghouse Electric and Manufacturing Company. He was engaged in general industrial sales work for the Westinghouse company until 1912, when he began to specialize in steel mill electrification. His experience with the company's marine propulsion activities during the war aided him in this special study. He was made manager of the industrial division in 1923, which position he held until his present appointment.

For many years Mr. James has been active in the local sections of the American Institute of Electrical Engineers and the Iron and Steel Electrical Engineers, serving as secretary of each organization. From 1918 to 1919, Mr. James was chairman of the Philadelphia section of the American Institute of Electrical Engineers. In 1921-22, he was president of the Engineers Club of Philadelphia.

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Success is paid for in just one currency—"Concentration"—and the degree of one's concentration measures the amount of his success. Anyone who tries to buy Success with any other coinage finds it discounted to the intrinsic value of whatever of concentration his special coinage contains, and the heavy discount makes many a man sore and discouraged. Many people try to gain Success, but get disgruntled because they can't get it by offering dross. Lots of folks always "holler" for more pay, who spend one-half their money loosely. They won't concentrate and they do not get ahead.

See those who have succeeded in their special lines. Take the world's money-makers! They decided to have GOLD and every waking moment of their lives they concentrated toward that one goal of Success. They braved the scorn and hate of

many of their fellow-men. They sacrificed friends, they schemed and cajoled for money, they forewent intellectual pleasure, society, and attained money. They know little about culture, art, literature, science or the meaning of religion. But, they got money, they developed a natural talent and became geniuses in their lines, by uncompromising concentration, and Success in their chosen fields was given in exchange. A sordid kind, perhaps, but "heart's desire" for them.

Consider the men whose aims were scientific knowledge. They forewent most of life's amenities and concentrated their all, health included, toward that Success—often attacked, hated, despised, anathematized, sick and weakly, they count but gain the loss they suffer because they know they are the foremost of their time in the line they choose.

Most folks want Success according to their own definition—but shun to pay the enormous price. They want to spread around. No man can be a "top-notcher" in business, society and good fellowship all at once. You can't spend $10 and keep it, too. There is no back alley short-cut to Success. Concentrate on our ambition, and we'll gain the Goal, but it costs high—so high that most people take the half-way, good-enough-for-me course, and perhaps are happier and better citizens for it. But, don't complain if you don't get what you call Success, unless you are willing to concentrate everything on attaining it.

And often it makes us very angry to think that most of the growlers, soreheads and knockers are those who won't concentrate, yet expect to succeed, and who get out of sorts with things in general instead of with their own sweet selves. (Trumbull Cheer.)

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Allis-Chalmers Mfg. Co. is opening a branch sales office at Houston, Texas, in charge of R. I. Moore, who was previously located in their Dallas office. Temporary quarters are at 231 Rodgers Building and after the first of the year the office will be located permanently at 1108 Post Dispatch Building. With the establishment of this office, the company will be able more affectively to serve its many customers in this territory.

The Houston office will be operated as a branch of the Dallas district, of which E. W. Burbank is District Manager.

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The Monitor Controller Company, Baltimore, Maryland, has developed a new hoist control outfit, consisting of a reversing controller with rope-operated-control master station.

This outfit is intended for use on traveling cranes, chain and rope hoists, or similar applications requiring a compact and substantial outfit possessing desirable safety features.

The equipment is of standardized design and intended for direct current and polyphase alternating current motors that are thrown across the line for starting.

The controller essentially consists of enclosed type two double pole mechanically interlocked contactors having graphite-to-copper contacts, blowout magnets and suitable barriers, all mounted on 8″ x 7″ panel. The overall dimensions of the controller are 8½″ x 10½″ x 6″.

The control master is of the fully enclosed self-centering type and intended for rope operating. It is always in the "off" position, except when held forcibly by the operator in either "forward" or "reverse" position. Dimensions of the station are 3½″ high and 3″ deep through. Bosses cast on the station housing, take the pull of the operating rope, and protect the contacts from mechanical damage.

---

A new, "ready-to-use" housing framework for Type FK-54 oil circuit breakers is now being manufactured by the General Electric Company, designed primarily to meet the demand for equipment which can be installed with a minimum of skilled work.

The three runways of the framework are welded in one solid piece, forming a base plate to which is welded an overhead structure of angles and steel straps. While the design is simplified, there is sufficient strength to hold bushings, contacts and runways in permanent alignment. To install, it is merely necessary to run the housing into the cell, secure it with grouting through the base plate and make the usual connections.

Units are securely interlocked against any attempted withdrawal of closed breakers, and there is a positive interlock between tripping coils so that the opening of one unit opens the entire circuit. A grounding device on each breaker, consisting of a long blade on the housing which engages a spring clip on the unit, gives grounding protection until the main contacts have been separated three inches.

All single-pole units can be assembled one, two, three or four poles. At 7500 volts, the ampere capacities are 400, 600, 800, 1200, 1600 and 2000 amperes. The interrupting capacity is 10,500 amperes at 7500 volts for two, three, or four-pole operation.

Another advantage of this new housing framework is the simplification in locating the three top bushings, all time-consuming adjusting being eliminated. The bushings are so arranged that contacts are in perfect alignment before the housing leaves the factory. Although these bushings are removed for shipping and cannot be replaced until the housing is in its cell, a system of numbers and dowels enables the user to replace the bushings in the same alignment obtained at the factory. Mounting plates are not interchangeable. Rear bushings are shipped in proper location.

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Definite steps to further the progress of the structural steel industry by means of closer internal cooperation, by the application of the most approved business practices, and by the education of the public in regard to the advantages of structural steel, marked the annual convention of the American Institute of Steel Construction held at White Sulphur Springs, West Virginia, November 11 to 14 inclusive.

The members of the Institute to the number of 160, together with a number of the country's foremost engineers and architects attending the con-

vention as guests, were welcomed by C. Edwin Michael, President of the Virginia Bridge and Iron Company, Roanoke, Virginia. Mr. Michael reviewed the achievements of the Institute in the past, including the formulation of the 18,000 pound unit of working stress and the code of standard practice, and then outlined the steps which remain to be taken or encouraged by the Institute.

The keynote of Mr. Michael's address, and in fact of the whole convention, was struck, when in summing up, Mr. Michael said, "Sectional and group co-operation of members is necessary to eliminate duplication of expensive practices. Accurate cost finding, modern selling methods, economical distribution, and a campaign of intelligent and forceful publicity promoting the use of structural steel are essential for the success of all engaged in the industry." Mr. J. L. Kimbrough, President of the American Institute of Steel Construction, replied to the address of welcome.

During the business sessions that followed, the passage of a number of resolutions and the adoption of a new budget gave the board of directors the authority and the means to initiate a program of activity involving the recommendations made by Mr. Michael. This constructive action, according to the officers and directors of the Institute, makes the 1925 convention a mile-stone in the career of the American Institute of Steel Construction and in that of each individual member.

Aside from the strictly business sessions, a considerable portion of the convention's time was devoted to discussions of various technical phases of the industry. R. A. Storm, Manager of the structural department of the Morgan Engineering Company, Alliance, Ohio, delivered an address on "Electric Arc Welding and Its Application to Structural Steel," in the course of which he stated that tests conducted by his company in connection with the erection of an electrically welded frame for a twelve story building in Detroit showed that the joints held until they were subjected to nine times the safe load.

Speaking on the use of steel in residence, farm buildings, garages, and small apartments, Henry R. Brigham, Chairman of the Housing Committee of the National Association of Real Estate Boards, stated that such construction offered an almost untouched field for the expansion of the structural steel industry. As an illustration of the practicality of steel frame construction for such buildings he cited the fact that a builder who is now building small houses with steel frames and metal laths has found that the cost of the steel for a six room bungalow is about $75 less than the cost of wood joists, rafters, studs, and laths.

The need of further technical research in the structural steel industry was emphasized in a paper by Dr. George F. Swain, Professor of Civil Engineering, Harvard University. A paper by H. A. Frommelt, Consulting Engineer of Milwaukee, Wisconisn, urged the adoption of the apprenticeship system in the building trades. Among the other addresses delivered before the Institute were:

"The Fireproofing of Structural Steel," by B. C. Collier, President, Cement-Gun Company, Inc., Allentown, Pa.

"An Investigation to Determine the Cause of Rivet Failures in Driving," by A. L. Spencer, Jr., Pittsburgh Screw and Bolt Company. Pittsburgh, Pa.

"My Experience with Concrete and Steel in Building Construction," by Albert C. Martin, Architect and Engineer, Los Angeles, California.

"Structural Steel in Earthquake Areas," by John L. Clymer, Manager, Northern California Division, California Institute of Steel Construction.

"Tests of I Beams Encased in Concrete," by Dr. H. M. McKay, Dean Faculty of Applied Science, McGill University, Montreal, Canada.

"The Structural Steel Industry and Its Future," by H. A. Fitch, President, Kansas City Structural Steel Company, Kansas City, Kansas.

At the annual dinner held on the night of November 13 the members of the Institute, their wives and their guests, were addressed by Senator George H. Moses of New Hampshire, who spoke on the relationship between government and industry. That the men who frame and enact our laws are themselves unable to operate under them was cited by the Senator as an instance of the hampering effect upon business of unnecessary, harassing and contradictory legislation.

"Perhaps the most striking commentary upon the manner in which legislation, tax legislation in particular, affects our citizenry," said Senator Moses, "is to be found in the fact that each year an expert has to be sent from the Treasury Department to the Capitol to help senators and representatives prepare their income tax returns."

J. L. Kimbrough, Indiana Bridge Company, Muncie, Indiana, was re-elected president of the Institute for the ensuing year. The other officers: W. M. Wood, Mississippi Valley Structural Steel Company, Decatur, Illinois; Charles F. Abbott, of New York, and Leo H. Miller, of Cleveland, Ohio., were re-elected vice president, executive director and chief engineer, respectivly. C. E. Michael, Virginia Bridge and Iron Company, Roanoke, Virginia, was elected to the new office of second vice president.

The following were elected as new directors: W. S. Mosher, Mosher Steel and Machinery Company, Dallas, Texas; R. Llewellyn, Llewellyn Iron Works, Los Angeles, California, and C. E. Michael, Virginia Bridge and Iron Company, Roanoke, Virginia. N. W. Warren, Dominion Bridge Company, Montreal, Canada, was elected to fill the unexpired term of E. S. Mattice, Canadian Vickers, Ltd., Montreal, Canada.

The five men who formulated the standard specification of the Institute, involving the 18,000-pound unit of working stress, were elected as the first honorary members. Their names are: G. F. Swain, Professor of Civil Engineering, Harvard University; M. S. Ketchum, Dean of the College of Engineering, University of Illinois; E. R. Graham, of Graham, Anderson, Probst & White, architects, Chicago, Illinois; W. J. Thomas, Chief Engineer, G. B. Post & Sons, architects, New York, and W. J. Watson, president Watson Engineering Company, Cleveland, Ohio.

At the meeting of the Board of Directors, held on the afternoon of November 13, it was decided to hold the next annual convention at White Sulphur Springs, West Virginia, during the last week in October.

The Western Electric Company recently announced the appointment of Mr. E. P. McGrath as Sales Manager of their Brooklyn Supply House. Mr. McGrath succeeds Mr. W. D. Koch, who was transferred to the Sales Department of the Western Electric Boston Supply House.

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Mr. C. E. Phillips has been appointed representative in charge of Wilkes-Barre office of the Allis-Chambers Mfg. Co. Mr. Phillips, who was formerly connected with the Philadelphia office of the company, succeeds Mr. Guy V. Woody.

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One of the outstanding developments in the transformer art in recent years is the Pittsburgh Polyphase Transformer Structure, Pittsburgh Film Type Radiator and the Expansion Tank for Transformers.

These three developments are briefly described in Pittsburgh Transformer's Bulletin No. 2049, in such a manner as to present to the reader some of the advantages of the use of these developments as embodied in Pittsburgh Polyphase Transformer with Pittsburgh Expansion Tank and Film Type Radiator. Copies of this bulletin will be furnished upon request.

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Speed transforming devices are indispensable to many applications of the electric motor, and of the numerous speed reducers now available, the worm gear type is most widely adaptable because of its efficiency, reliability, compactness, and wide range of speed reduction afforded. It cannot, however, be applied for ratios much lower than 4 to 1, and the De Laval Steam Turbine Company, Trenton, N. J., has therefore supplemented its line of worm reduction gears by simple helical gear reductions.

The helical gear has the great advantages of uniform transmission of motion and absence of vibration, as well as noiseless operation. Large helical gears transmitting high powers are generally made with a double helix of opposing angles, in order that there may be no end thrust. However, for small helical gears transmitting moderate power, such as the one shown herewith, the double helix is not necessary, as the thrust generated is small and is easily taken care of by a thrust bearing, which in any event is necessary to properly locate the gears. A one piece casing insures maintenance of alignment of the gear and pinion and the maintenance of proper center distances. It also serves as a reservoir and container for the oil. For moderate speed conditions the pinion dips into the oil, thus lubricating the teeth, but for high speeds it is preferable to spray the teeth with oil from a pressure circulating system.

The gear shaft is fitted with an oil slinger and oil guards and the pinion is supplied with a split gland, which can be removed without disturbing the coupling or any portion of the reduction. These gear reductions are usually supplied with flexible couplings to avoid any strains from expansion or slight movement between the driving and driven machine. The casing is large and is raised above the foundations on four feet, permitting free circulation of cooling air beneath the casing, as well as around it.

Mr. W. H. Williams, better known throughout the steel industry as "Pete," has accepted the Vice Presidency of the Clark Controller Company, builders of electrical and mechanical apparatus at Cleveland, Ohio.

W. H. Williams
*Vice President, The Clark Controller Company, Cleveland, Ohio.*

Mr. Williams was formerly associated with the Electric Controller and Manufacturing Company, at Cleveland, O., later being in business under the name of W. H. Williams Company, at 53 West Jackson Blvd., Chicago, Ill.

For quite a number of years Mr. Williams was the District Secretary of the Chicago Section of the Association of Iron and Steel Electrical Engineers. His legion of friends wish him well in his new venture.

---

The De Laval Steam Turbine Company, Trenton, N. J., catalogue No. E-1076, describes Tulsa's $7,500,000 water supply station. The pumping station contains two 12,000,000 gallon per day De Laval gear turbine driven centrifugal pumps, which force the water against 350 foot head through 4 miles of 30" steel main to a covered 10,000,000 gallon concrete high service reservoir. Applications for bulletin E-1076 will be honored.

---

The Youngstown Sheet and Tube Co., Youngstown, Ohio, recently placed orders for electrical equipment to drive a seamless tube mill. The mill will be driven by a 2000 H.P. 600-volt 230-360 R.P.M. direct current motor, a 1200 H.P., 6600-volt, 3-phase, 60-cycle wound rotor motor and 4—450 H.P. 2200-volt, 3-phase, 60-cycle, 720 R.P.M. synchronous motors. The Westinghouse Electric and Manufacturing Co. will supply the electrical equipment.

---

The Midland Coke and Iron Corporation, formerly the St. Louis Coke and Chemical Company, has let the contract for:

One 500 ton blast furnace to the Riter Conley Company of Pittburgh, Pa.

Contracts have been let for the following:

Two 5000 KW Turbo Generators to Allis Chalmers Mfg. Company.

One 50,000 cu. ft. Turbo Blower to Ingersoll Rand Company.

Main Switchboard and Motor Generator to Westinghouse Electric and Mfg. Company.

Three 800 HP Boilers to Babcock and Wilcox Boiler Company.

Stokers to Illinois Stoker Company.

The Sub-Station bus is tied in through a 10,000 KVA transformer bank with the local power company who have arranged to purchase all the excess power developed by the Midland Coke and Iron Company.

This is another instance where the advantages of the interchange of power is recognized and appreciated.

Mr. G. R. Thatcher, an active member of the Association of Iron and Steel Electrical Engineers is the electrical engineer of this plant.

Mr. Shover, who installed all the electrical apparatus at the Gary Works of the Illinois Steel Company and who was general manager of the Brier Hill Steel Company and general manager of the Tata Iron and Steel Works of India will be in charge of all power requirements of the Midland Coke and Iron Corporation.

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Gordon Fox, who was formerly associated for many years with the steel companies in and around Chicago, and now with the Freyn Engineering Company, was just recently elected Secretary of the Chicago District Section.

Mr. Fox's activities with the Association dates back about ten years, and his editorial contributions

GORDON FOX

*Elected Secretary, Chicago District Section.*

to the proceedings of the Association has been of value to the Engineers in the Steel Industry.

Mr. Fox is thirty-eight years old, was born in Milwaukee, Wisconsin, graduated from the Madison High school in nineteen hundred and four. Like most successful men, Mr. Fox, in his boyhood days, operated a newspaper route and graduated to night work in a newspaper office, the earnings of which helped him through school. In nineteen hundred and eight he graduated from the University of Wisconsin with the degree of Electrical Engineer.

In nineteen hundred and eight he was associated with the Northern Electric Manufacturing Company at Madison, Wisconsin, which was later taken over by the Fort Wayne Works of the General Electric Company. Until nineteen hundred and twelve he was employed by this company as an erector and service expert, from nineteen twelve to nineteen fourteen specialized in motor applications in the industrial plants in and about Chicago.

In nineteen hundred and fifteen accepted a position as Electrical Engineer with the Mark Manufacturing Company at Evanston, Illinois. During this period he was in charge of the development of an experimental machine for welding the longitudinal seam of pipe at high-speed electrically, the experiments meeting with considerable success. From nineteen hundred and fifteen to nineteen hundred and twenty he was engaged with the Steel and Tube Company of America as Electrical Engineer. During this period he acted as engineer in charge of electrical design, construction and initial operation of new mills comprising coke ovens, blast furnace, open hearths, blooming mill, finishing mills and power house.

In nineteen hundred and twenty he became associated as Electrical Engineer with Freyn, Brassert & Co. and Freyn Engineering Co.

Mr. Fox has displayed more than ordinary literary ability and his principles of electric motors and control may be found in the engineering departments in practically all of the industrials.

The Chicago District Section has chosen wisely in their selection of a Secretary.

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## ENGINEERING ACHIEVEMENTS FOR THE YEAR 1925

(Continued from Page III)

presses, textile mills, labor-saving devices in the home, and a multitude of other industries in ever-increasing numbers.

Generating units of a size never before thought possible are in course of construction. Synchronous condensers and frequency changer sets of greater size and efficiency than ever before attained have been placed in operation. The greatest locomotives ever built are moving coal from the West Virginia fields with an ease and smoothness of operation considered impossible a few years ago. Diesel electric drive has been applied to ships, making possible the centralization of their control in the pilot house, with the result that vessels so equipped can be handled with the ease of a modern automobile. Many other illustrations might be given.

Even those engaged in the electrical industry cannot fully appreciate or understand the many and tremendous problems that are being solved; only these modest scientific men who are doing the work really know. It is fitting, therefore, to look backward as the year closes, and briefly enumerate some of their more outstanding achievements, commending them for their work well done, confident that in the coming year their efforts will be crowned with renewed success.

# MEETINGS AND PAPERS

## Pittsburgh Section

**C. S. PROUDFOOT, Chairman** **R. F. CHAFFIN, Vice Chairman**

## Saturday, January 16th, 1926

**Blue Room, William Penn Hotel** **Pittsburgh, Pa.**

**Dinner 6:30 P. M.** **Meeting 8:00 P. M.**

**Entertainment 5:30 P. M.**

## MAIN ROLL DRIVES

By L. A. UMANSKY, General Electric Co.,
Schenectady, N. Y.

The Entertainment Committee has provided for this meeting an unusual treat, and you are invited to be present at 5:30.

## Philadelphia Section

**H. S. BOONE, Chairman** **LINN O. MORROW, Secretary**

## Saturday, January 9th, 1926

## THE APPLICATION OF HIGH DUTY WORM GEARS IN STEEL MILL PLANTS

By ARTHUR HENTHORN, Engineer, Dravo Doyle Co.,
Philadelphia, Pa.

All Philadelphia Meetings unless otherwise noted are held in the Engineers' Club at 1317 Spruce Street and will start promptly at 8:00 P. M. They are always preceded by an informal dinner at 6:00 P. M.

The privileges of the Engineers' Club are at the disposal of the A. I. & S. E. E. members on the day of the meeting. Make the club your headquarters.

# SAFETY CONGRESS

Auspices

# SAFETY DIVISION

## Association of Iron and Steel Electrical Engineers

**Wednesday, March 10th, 1926**

**Thursday, March 11th, 1926**

**PITTSBURGH, PA.**

## Safety and the Electric Overhead Traveling Crane

**EMPLOYING AND TRAINING CRANE OPERATORS.**

A. Physical examination.
B. Mental and physical co-ordination.
C. Course of training and cost of training.
D. Should dependence be placed on strict enforcement of crane rules or men allowed to use own judgment in unusual conditions.
E. Is better service secured by penalizing delays or by personal safety advice?

**RULES FOR SAFE CRANE OPERATION**

A. Crane operator's rules.
B. Crane director's rules.
C. Signals to be used between Crane Operator and Crane Director.

**CRANES.**

A. Ladders.
B. Steps.
C. Walks.
D. Platforms.
E. Gear Guards.
F. Fire hazards in cabs.
G. Switches.
H. Location of switches.
I. Manual or magnetic control.
J. Hoist limit switches.
K. Exposed current carrying parts
L. Falling crane parts.
M. Failure of ropes.
N. Daily inspection.

**RUNWAYS.**

A. Signals.
B. Rules for workmen on runways.
C. Approaches to runways.
   A. Ladders.
   B. Platforms.
   C. Steps.
D. Rail stops.

**GENERAL.**

A. Rules for protection of workmen on floor.

Safety Directors, Electrical Engineers, Operating Superintendents, Crane and Electrical Manufacturers, Safety Device Manufacturers, are invited to attend.

# The Clark Controller Co.

CLEVELAND,
OHIO

ANNOUNCING

## JANUARY—1926—DELIVERY

ON THE

## CLARK MANUAL CONTROLLER

FEATURING

Pressed Steel Frame
Non Breakable Resistance
Other Points of Interest
A Face Plate Type Controller

Also

## THE "THREE C" BRAKE

Electrically or Mechanically Operated

Featuring

Band Brake Efficiency
Shoe Brake Principle
Ease of Adjustment

*Write for Prices and Additional Information*

# The Clark Controller Co.

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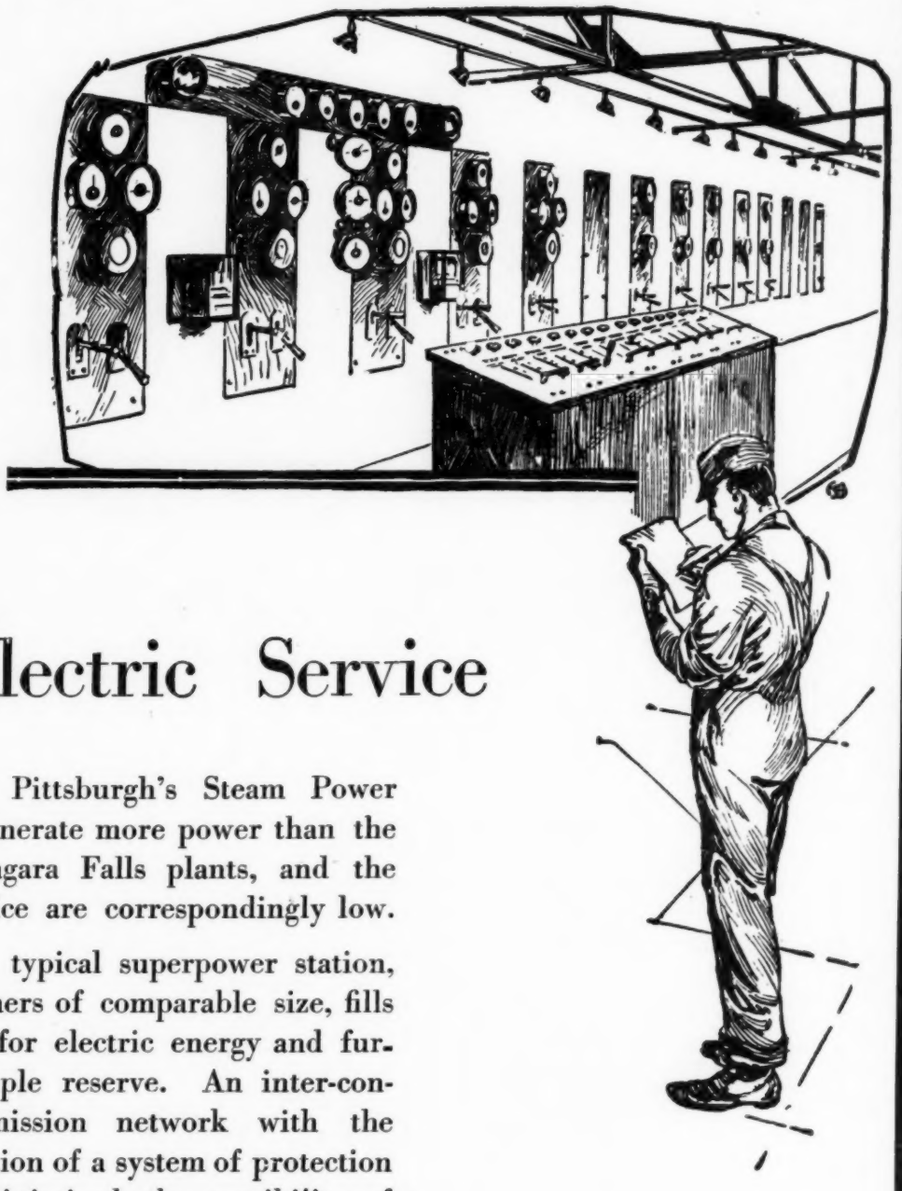
CLEVELAND,
OHIO.



# Good Electric Service

GREATER Pittsburgh's Steam Power plants generate more power than the American Niagara Falls plants, and the rates for service are correspondingly low.

Colfax, the typical superpower station, along with others of comparable size, fills the demands for electric energy and furnishes an ample reserve. An inter-connected transmission network with the recent installation of a system of protection has greatly minimized the possibility of service interruptions.

With such dependable electric service Pittsburgh offers unusual inducements for new industries. We welcome inquiries concerning light and power facilities in any section of the Pittsburgh District.

*"Live in and Expand Your Business in Greater Pittsburgh"*

## DUQUESNE LIGHT COMPANY

435 Sixth Avenue : : : Pittsburgh, Pa.

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WHEN you need brushes on short notice for any reason *write, wire* or *phone* the nearest of our four plants, and the National Pyramid Brushes you need will be on their way to you immediately.

Have we complete data sheets on your motors, generators and converters? Information regarding our data sheet service gladly sent on request.

*The services of our Sales Engineers are always at your disposal*

*Manufactured and guaranteed by*

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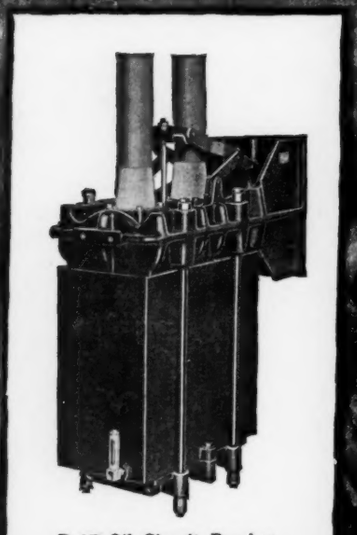
Barker Place
*Phone:* ATLantic 3570

NEW YORK, N. Y.
357 West 36th St.
*Phone:* LACkawanna 8153

# Energy Absorption



D-17 Oil Circuit Breaker

When railroad trains clank over rail joints, the SPRING SUSPENSION of the heavy car bodies takes up the shock—protects trucks, track and freight from damage—safeguards passengers and crew from discomfort and danger.

And when the CONDIT D-17 Oil Circuit Breaker opens a high power circuit it's the SPRING SUSPENSION of its tank construction that takes up the impact of expanding gases—protects the breaker from impairment—safeguards life and property, and the service of your plant, from possible hazard. Get Advance Bulletin No. 445-3.

**CONDIT ELECTRICAL MFG. CORP.**

*Manufacturers of Electrical Protective Devices*

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Northern Electric Company, Ltd.

Sole Distributor for the Dominion of Canada

*SPECIFICATIONS*: 1, 2, 3 *and* 4 *Pole, Manually and Electrically Operated; up to* 1,600 *amperes,* 7,500 *volts*; 1,200 *amperes,* 15,000 *volts;* 600 *amperes,* 25,000 *volts. Interrupting capacity,* 6,000 *amperes at* 15,000 *volts.*

CONDIT

# Big Helps in Your Heat Treating Operations

Here are a few of the new Ryan Bulletins on Standardized Heat Treating Equipment. They are fully illustrated and contain clear and concise data on coal, gas, oil and electric equipment that will assist materially in improving your present heating or heat treating operations. There's a full set of these valuable bulletins waiting for you here—a line from you will bring them right to your desk.

Your chief engineer, your production manager, and your plant superintendent will appreciate the fund of information contained in these Ryan Bulletins. They will be glad to know that standardized heating equipment such as Ryan builds can be secured in sizes and types to meet practically every need of the average industrial plant.

Have your secretary write at once for a complete set of the Ryan Bulletins on Standardized Heat Treating Equipment.

[ *Before investing in any new equipment for heat treating, consult Ryan engineers. Let them point out the many economies resulting from the installation of Ryan Standardized Furnaces or Heat Treating Equipment--over 60 products in number.* ]

Ryan Heating Service For all Industries

**Plant Surveys and Layouts**
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**Design and Construction of**
**(a) Standard Equipment**
**(b) Special Equipment**
**Re-design of Old Equipment**
**Actual Construction and Supervision**

## F. J. RYAN & COMPANY

**1701 Arch St., Philadelphia.**

**Hartford, Baltimore, Buffalo, Detroit, St. Louis, Indianapolis, San Francisco.**

# RYAN

## STANDARDIZED HEAT-TREATING EQUIPMENT

"SCRAP YOUR CRANE if

it is causing costly delays in production—if the bother and expense of operating, maintaining and repairing is excessive."

That's the substance of the remark made by an industrial executive when he planned replacing a low first cost but expensive crane, with a P & H.

# Buy Crane Service

THERE is only one reason for a crane—*service*. P & H Crane service is low cost handling service because the crane is *right* in the first place.

P & H does more than meet specifications. Instead of working down to them, P & H works up from them.

Metallurgists test all metals; steel plates purchased as flat plates are nevertheless re-rolled to give absolute insurance against the slightest strains; every type of modern machine tool is employed—all supervised by executives who have for 41 years insisted on precise workmanship.

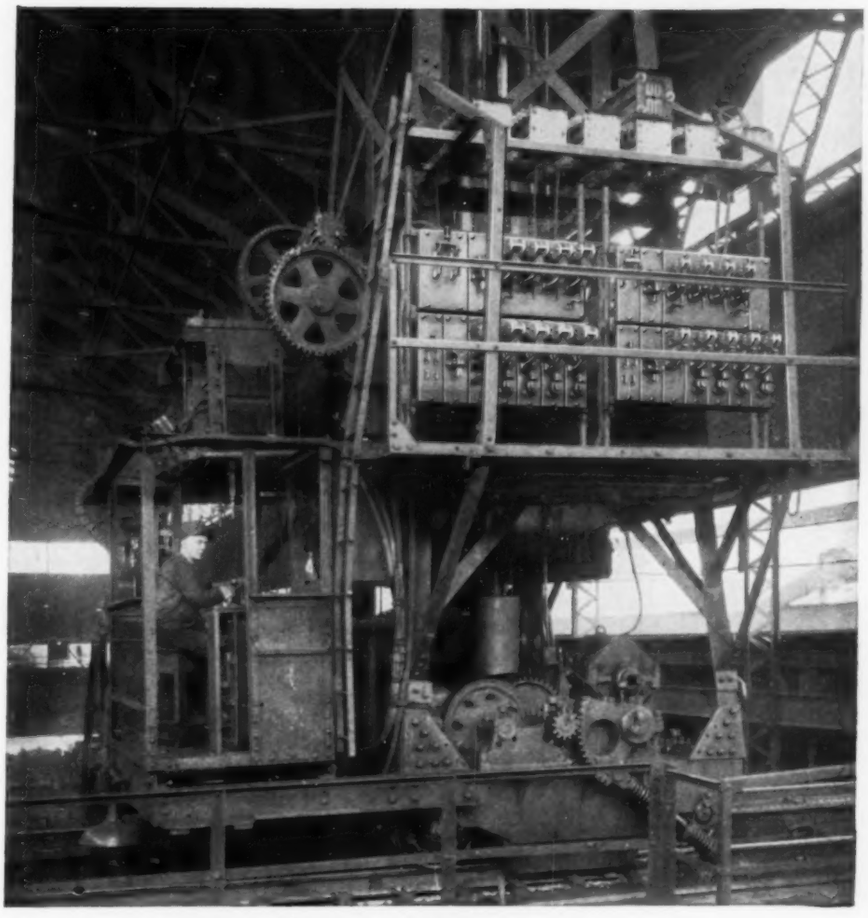
That this has been appreciated is evidenced by the 8,000 P & H Traveling Cranes and Hoists that have gone into service.

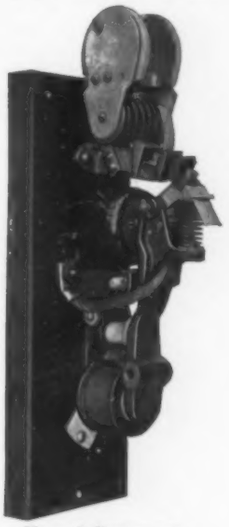
HARNISCHFEGER CORPORATION
Successor to
PAWLING & HARNISCHFEGER CO.
*CRANE AND HOIST DIVISION*
Established in 1884
3855 National Avenue, Milwaukee, Wis.

*New York Chicago Kansas City Dallas Memphis*
*Philadelphia Pittsburgh Detroit Birmingham Jacksonville*
*San Francisco, Portland, Los Angeles, Seattle, Minneapolis*

P&H CRANES and HOISTS

# Cutler-Hammer Inductive Time-Limit Controllers





**Easy Adjustment of Accelerating Time**

*The accelerating time may be varied by adjusting the magnetic gaps on the holding-out magnets of the accelerating contactors as this adjustment varies the pull exerted by this magnet; consequently this magnet lets go at different values of secondary current. The construction of the contactor, the contacts, blowout, magnet structure, and coil are exact duplicates of standard C-H shunt butt contactors. The only difference is that a holding-out magnet with its adjustments is added.*

**Master Controller Has Two Bearings**

*Two bearings are provided which improve the operation. An oiling pad continually lubricates the contacts and reduces wear on these surfaces. The supporting bar holding the fingers is out of the way of any copper dust that may fall from the fingers. Terminals are accessible and wiring made easy.*

## Greater Tonnage

### C-H *Inductive Time-Limit Controllers provide the kind of control necessary*

MAXIMUM output of the motors,—continuity of operation,—acceleration with no variation in the time period,—C-H Inductive Time-Limit Controllers provide these advantages.

The inductive principle is utilized to obtain the accelerating time,—there are no dash pots, relays, interlocks, or other mechanical or electro-mechanical devices for obtaining timing. The result is—extreme simplicity, ruggedness and dependability.

If you are interested in getting the utmost out of your motor drives—let us acquaint you with the advantages of C-H Inductive Time-Limit Control.

**THE CUTLER-HAMMER MFG. CO.**

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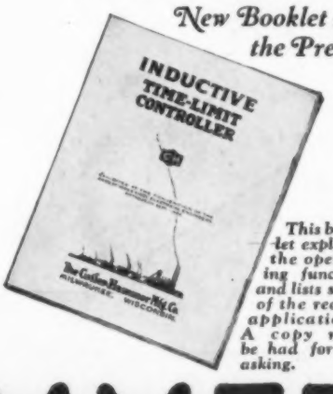
Chicago: 323 N. Michigan Ave. — Cleveland: Guardian Building — St. Louis: 2111 Railway Exch. Bldg.
Pi tsburgh: Century Building — Boston: 52 Chauncy Street — Buffalo: 358 Ellicott Square Bldg.
Milwaukee: 530 Grand Avenue — Cincinnati: Dixie Terminal Building

*Inquiries from the Pacific Coast may be directed to the H. B. Squires Co., Los Angeles, San Francisco, Portland, Seattle*

*Northern Electric Co., Ltd., Canada*

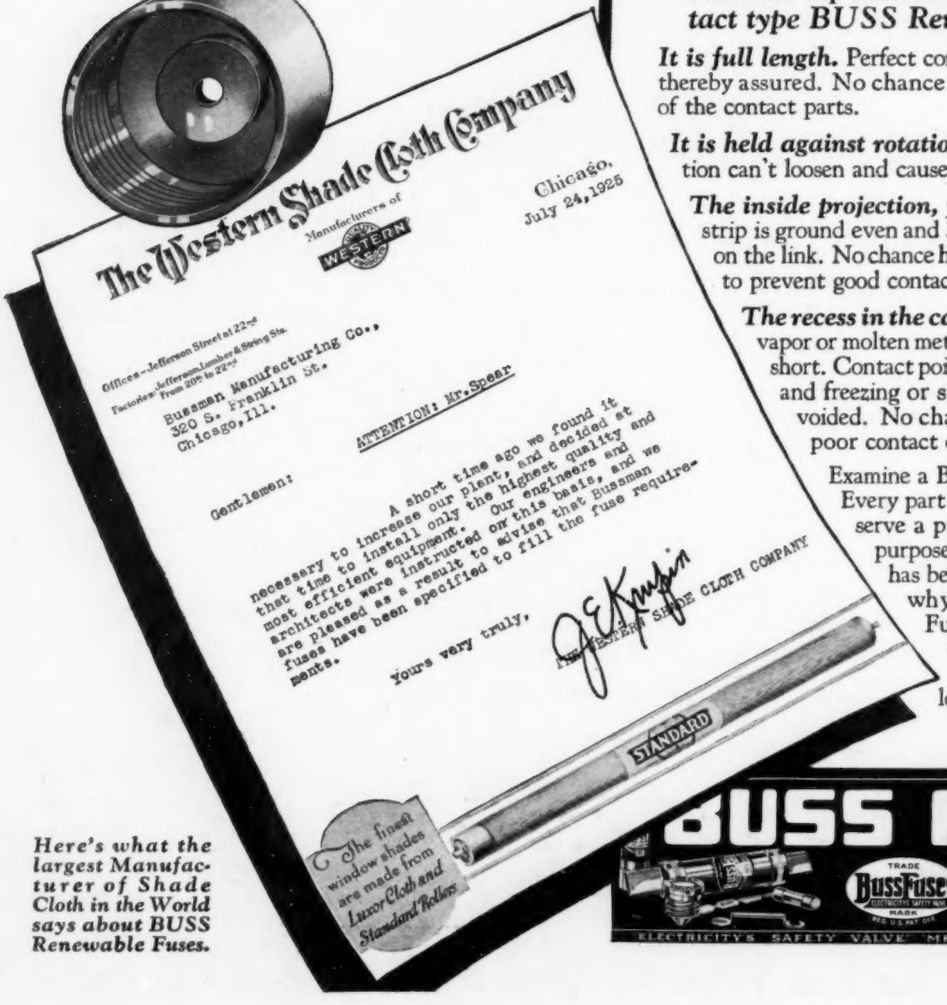
***New Booklet off the Press!***




*This booklet explains the operating function and lists some of the recent applications. A copy may be had for the asking.*

# CUTLER-HAMMER

*Pub. C-1012*


The Western Shade Cloth Company
Manufacturers of
WESTERN
Chicago,
July 24,1925
Offices—Jefferson Street at 22nd
Factories—Jefferson, Lumber & Strong Sts. From 20th to 22nd
Eusaman Manufacturing Co.,
320 S. Franklin St.
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ATTENTION: Mr. Spear
Gentlemen:
A short time ago we found it necessary to increase our plant, and decided at that time to install only the highest quality and most efficient equipment. Our engineers and architects were instructed on this basis, and we are pleased as a result to advise that Busaman fuses have been specified to fill the fuse requirements.
Yours very truly,
THE WESTERN SHADE CLOTH COMPANY
STANDARD
The finest window shades are made from Luxor Cloth and Standard Rollers

*Here's what the largest Manufacturer of Shade Cloth in the World says about BUSS Renewable Fuses.*

## *The BEST Obtainable Electrical Protection at the Lowest Operating Cost*

The Underwriters label of approval and the confirmation of thousands and thousands of actual fuse users through all of North America are your warranty of Electrical Protection.

The few parts and the simplicity of their design make ease and speed of renewal instantly apparent. That same simplicity of design insures long life.

***Note the cap used on the ferrule contact type BUSS Renewable Fuse.***

***It is full length.*** Perfect contact with the clips is thereby assured. No chance for varying diameters of the contact parts.

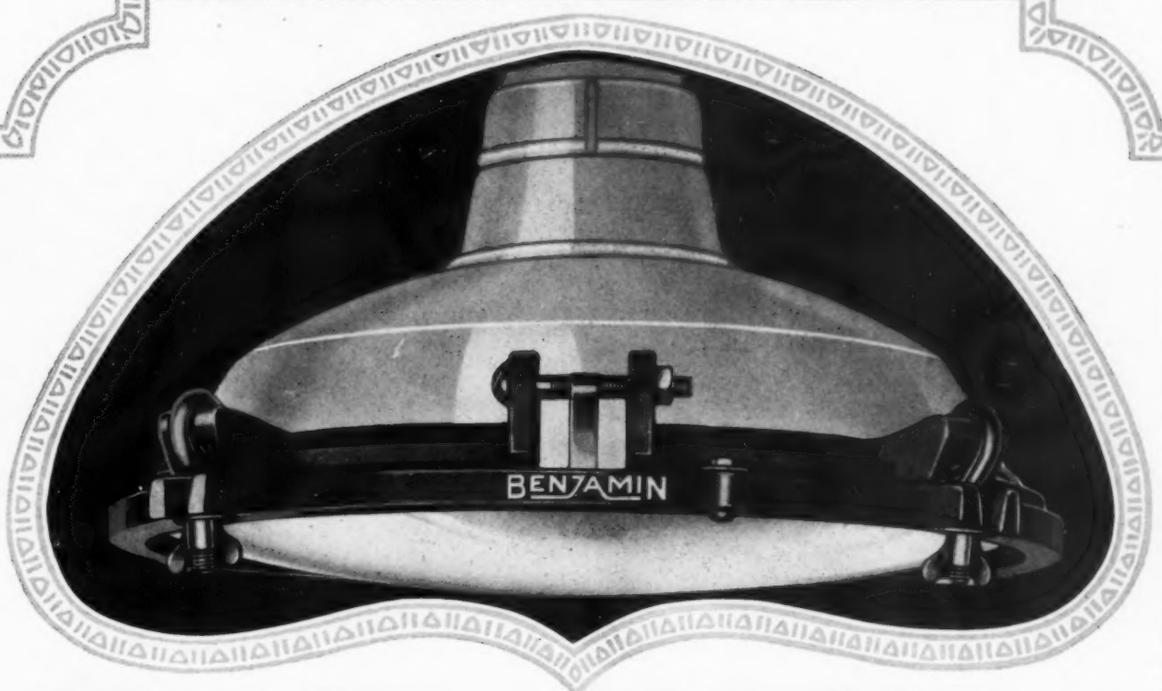
***It is held against rotation*** by the clips. Vibration can't loosen and cause poor contact.

***The inside projection,*** just the width of the strip is ground even and smooth. It bears only on the link. No chance here for foreign matter to prevent good contact.

***The recess in the cap*** takes up all metallic vapor or molten metal expelled on a heavy short. Contact points are thus protected and freezing or sticking of the caps avoided. No chance here either for poor contact on the next renewal.

Examine a BUSS renewable fuse. Every part has been designed to serve a particular and useful purpose. Every useless part has been eliminated. That's why BUSS Renewable Fuses give the best obtainable Electrical Protection at the lowest operating cost.

**Send for a Sample**




# Dirt-Proof Lighting

## *with Benjamin Heavy Duty Dust Tight Glass Covers*

The efficiency of a lighting system is dependent upon the useful hours of maximum lighting intensity. Obscure the light with a film of dust and dirt and you get less illumination, but you pay for the light just the same.

Benjamin Dust-Tight Glass Covers protect the reflector surface and lamp in dusty, dirty, smoky places. They seal the reflector and lamp in their original cleanliness and high efficiency. They maintain good illumination at its high point and reduce maintenance costs.

The Dust-Tight Glass Cover also acts as a protection to the reflector lamp. Made of heavy annealed clear glass, in a two-piece cast aluminum ring, which encloses a circular molded rubber gasket, making the cover dirt tight and protecting the glass from injury. It is hinged to permit an easy change of lamps, and is easily attached to most of the Benjamin reflectors you have already installed.

Don't let dirt defeat your better lighting plans. The original cost of the Dust-Tight Glass Cover is small compared with the gains in efficiency and maintenance. Any of our offices will gladly furnish specific information.

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Manufactured in Canada by the Benjamin Electric Mfg. Co. of Canada, Ltd., Toronto, Ontario

**BENJAMIN**

*Less* than 200,000 dots on this page. *More* than 200,000 Johns-Manville Steam Traps in service. It's the simplest and best steam trap made

**JOHNS-MANVILLE**

JOHNS-MANVILLE Inc., 292 Madison Avenue at 41st Street, New York City
*Branches in 64 Large Cities* For CANADA: CANADIAN JOHNS-MANVILLE CO., Ltd., Toronto

# SAFETY SWITCH CONDULETS

*Type MT—Without Hub Plates Door Closed*

## TYPE MT

**FOR SMALL MOTORS OF 30 AMPERES OR UNDER**

**ALL LIVE PARTS COMPLETELY ENCLOSED IN A DUST-TIGHT CONDULET**

*Type MT—Without Hub Plates Door Open*

WHEN SWITCH IS CLOSED DOOR CANNOT BE OPENED
WHEN DOOR IS OPEN SWITCH CANNOT BE CLOSED

SWITCH MAY BE LOCKED IN THE "ON" or "OFF" POSITION

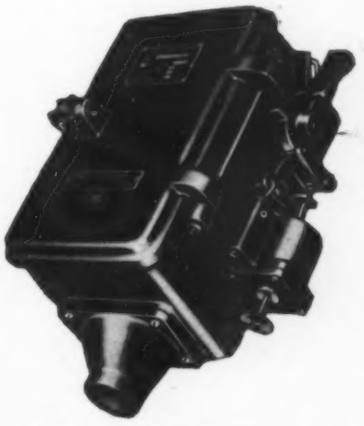
CAN BE FURNISHED WITH AN UNDER-VOLTAGE RELEASE COIL

COIL RELEASES AT 50% OF NORMAL VOLTAGE

CONDULET HAS REMOVABLE CONDUIT HUB PLATES

*Type MT—With Hub Plates Door Open*

*Price and Detail Description on Application*



*Type MT—With Hub Plates and Under Voltage Release Coil*

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PHILADELPHIA DETROIT CINCINNATI MINNEAPOLIS SAN FRANCISCO

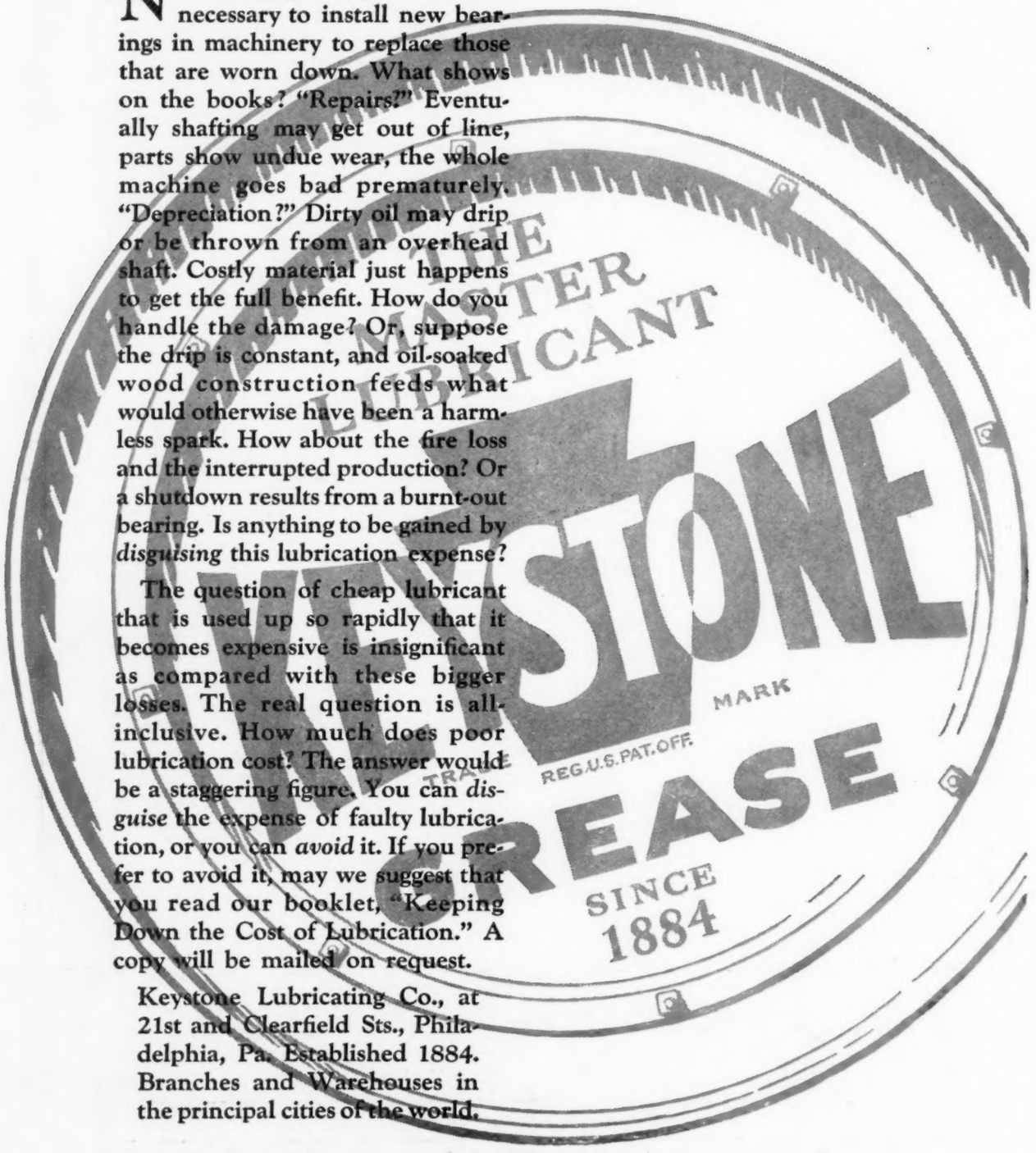
CH 167

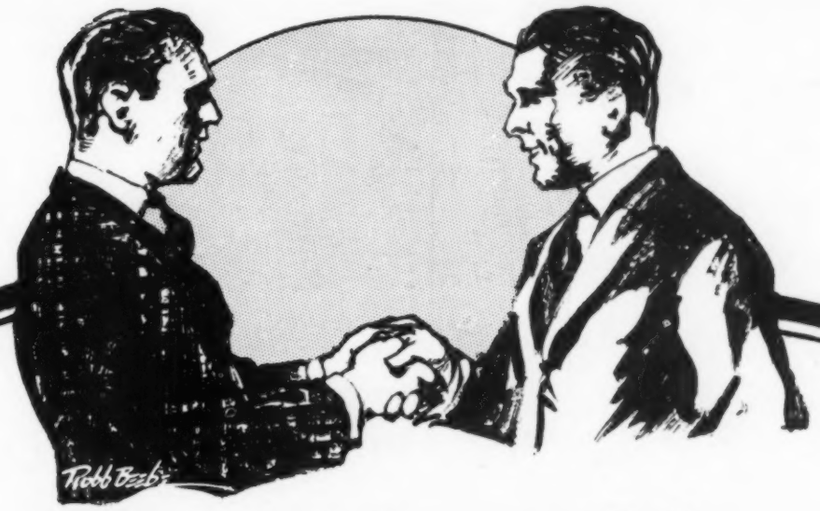
# You Can *Disguise* the Expense of Faulty Lubrication or You Can *Avoid* It

NOT infrequently it becomes necessary to install new bearings in machinery to replace those that are worn down. What shows on the books? "Repairs?" Eventually shafting may get out of line, parts show undue wear, the whole machine goes bad prematurely. "Depreciation?" Dirty oil may drip or be thrown from an overhead shaft. Costly material just happens to get the full benefit. How do you handle the damage? Or, suppose the drip is constant, and oil-soaked wood construction feeds what would otherwise have been a harmless spark. How about the fire loss and the interrupted production? Or a shutdown results from a burnt-out bearing. Is anything to be gained by *disguising* this lubrication expense?

The question of cheap lubricant that is used up so rapidly that it becomes expensive is insignificant as compared with these bigger losses. The real question is all-inclusive. How much does poor lubrication cost? The answer would be a staggering figure. You can *disguise* the expense of faulty lubrication, or you can *avoid* it. If you prefer to avoid it, may we suggest that you read our booklet, "Keeping Down the Cost of Lubrication." A copy will be mailed on request.

Keystone Lubricating Co., at 21st and Clearfield Sts., Philadelphia, Pa. Established 1884. Branches and Warehouses in the principal cities of the world.





# It's Like Friendship

A feeling exists between a commutator and its Stackpole Brush—a feeling of mutual respect that amounts to friendship.

Chattering, high mica, heating, flat spots — STACKPOLE CARBON BRUSHES prevent them all. Smooth, glossy commutators are always to be found wherever Stackpoles are installed.

No matter where you use Carbon Brushes—you'll find a type of Stackpole Brush admirably suited for your purpose. Let Stackpole Engineers make a study of your brush requirements and show you how you can obtain better commutation and longer life with STACKPOLE Carbon Brushes.

# STACKPOLE

CARBON BRUSHES

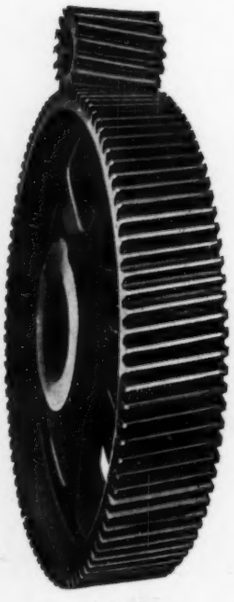
STACKPOLE CARBON COMPANY

ST. MARYS PA.

# Nuttall

## A four-word Classification

### of Nuttall Products for Mill Service



Nuttall Helical Gear Set

## Dependable

## for Heaviest Duty

Type B Spring Buffer Coupling

This is an especially rugged reversible cast steel, spring buffer coupling, adapted to heavy loads and moderate speeds.

**Experts at your service for Consultation**

R.D. NUTTALL COMPANY
PITTSBURGH PENNSYLVANIA

**Philadelphia Office**
Westinghouse Bldg.,
30th and Walnut Sts.

**Chicago Office**
2133 Conway Bldg.

**Canadian Agents—Lyman Tube & Supply Co.**
Toronto—Montreal.

# AIR!

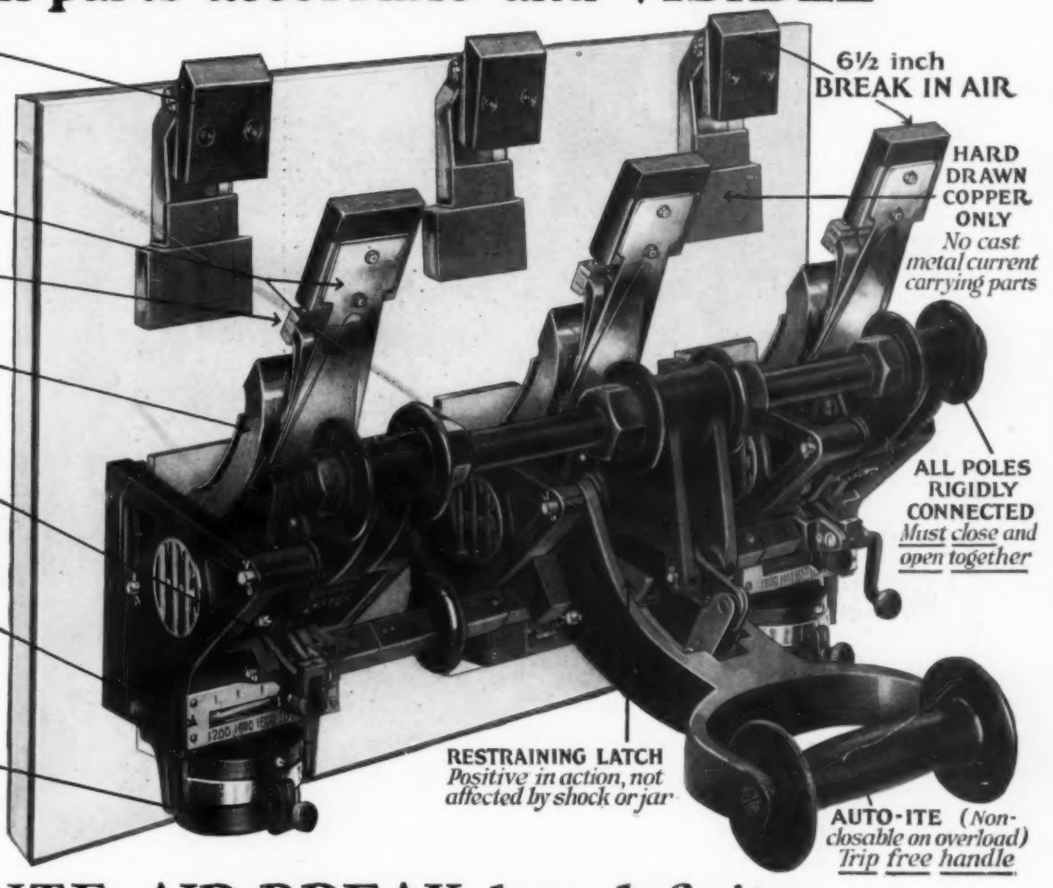
# I-T-E CIRCUIT BREAKERS

*For Alternating Current*

## 600 VOLTS OR LESS

## Give protection without complication

## All parts accessible and VISIBLE

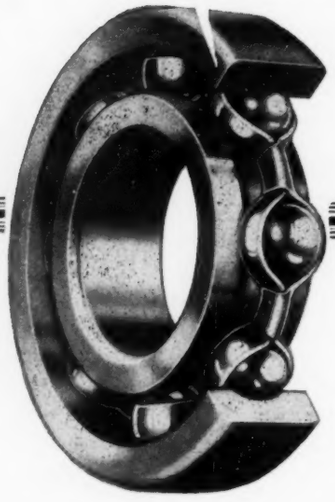

COPPER JACKETED PRESSURE CARBONS
For initial contact and final break
Mechanically strong
Electrically perfect
PHOSPHOR BRONZE CARBON SUPPORTS
HEAVY METALLIC SECONDARY BREAKING CONTACTS
LAMINATED BRIDGE
Each leaf individually formed - Heavy even pressure on every Lamination
CLOSING TOGGLES
Afford heavy contact pressure with easy closing
OVERLOAD
Direct acting. Long scale calibration. No relays or series transformers
DALITE
(Direct acting time limit) feature. Adjustable from zero to maximum time. No relays
6½ inch BREAK IN AIR
HARD DRAWN COPPER ONLY
No cast metal current carrying parts
ALL POLES RIGIDLY CONNECTED
Must close and open together
RESTRAINING LATCH
Positive in action, not affected by shock or jar
AUTO-ITE (Non-closable on overload)
Trip free handle

## I-T-E AIR BREAK has definite advantages not present in the oil breaker

1. *No oil — to leak, carbonize, burn or explode — Just air.*
2. *No tanks to conceal anything — or the lack of it.*
3. *No cells — nothing which needs or deserves to be imprisoned — Just a faithful and efficient servant.*
4. *Inherent simplicity — with resulting low cost of installation and maintenance.*

The I-T-E CUTTER COMPANY
ESTABLISHED 1888 PHILADELPHIA

1826 Hamilton Street



# Advantages of ball bearings for electric motors

## *XII.—Higher Efficiency*

Motor friction losses cost money—power money. And anything that reduces such losses means a real dollars and cents saving in the owner's pocket.

Here is where ball bearing motors show a decided advantage over motors of any other type.

Assume, for example, that a ball bearing motor is only 2% more efficient than a sleeve bearing motor of the same rated capacity—and this figure is conservative according to available comparative performance data. Then 30 motors, each delivering 10 H. P. and running 3,000 hours a year, would show an annual saving of 30 x 10 x 3,000 x .02 = 18,000 H. P. hours. At a cost of 2c a horsepower hour this would amount to a yearly saving in power of $360 for the 30 motors.

Note that this is a saving in power only. It does not include the corresponding savings in lubrication, maintenance and production losses already considered in previous advertisements of this series.

*THIS advertisement is the twelfth of a series appearing in this magazine monthly. Previous advertisements have summarized the following advantages of ball bearings for electric motors:*

1. *Short overall length of motors.*
2. *No shorts from oily windings.*
3. *Clean bearings.*
4. *Small, constant air gap.*
5. *Reduced maintenance costs.*
6. *Thrust load capacity.*
7. *Repair bills cut.*
8. *Smaller stock of spares.*
9. *Belted in any position from any direction.*
10. *International Interchangeability.*
11. *Long life.*

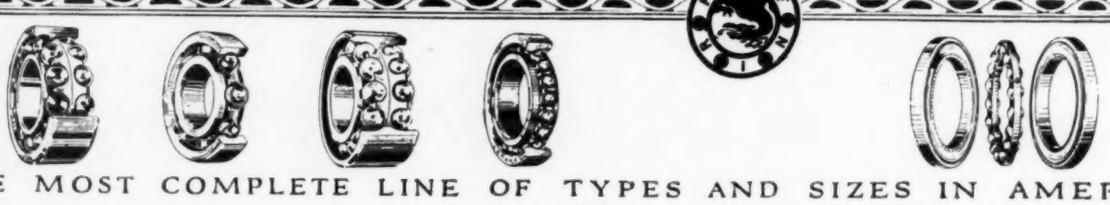
THE FAFNIR BEARING COMPANY

*Makers of high grade ball bearings, the most complete line of types and sizes in America.*

NEW BRITAIN, CONN.

Chicago Newark Cleveland Detroit

# FAFNIR
## BALL BEARINGS



THE MOST COMPLETE LINE OF TYPES AND SIZES IN AMERICA

# SYKES HERRINGBONE GEARS

CONTINUOUS TEETH—SHARP APICES

## GENERATED FROM THE SOLID

*Made in All Sizes*

**These gears are installed on cold strip mills where they have eliminated all tooth marks.**

**Sykes gears are essential on cold strip mills if high quality product is required.**

## *The Gear With a Backbone*

AMERICA'S FINEST

# FARREL FOUNDRY & MACHINE CO.

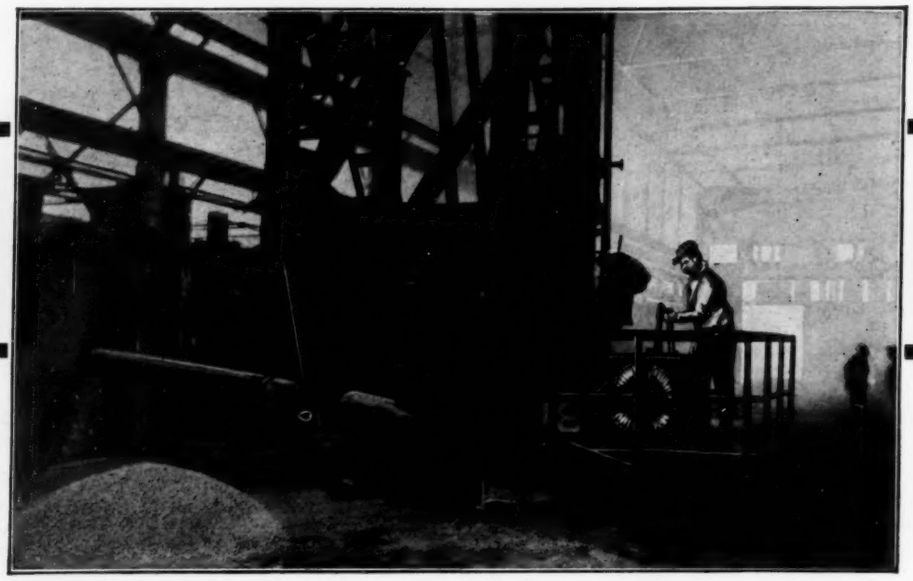
New York, N. Y., 15 Moore St.
San Francisco, Cal., 75 Fremont St.

Boston, Mass., 915 Little Bldg.
Cleveland, Ohio, 802 Swetland Bldg.
Pittsburgh, Pa., 649 Union Trust Bldg.

Havana, Cuba, Edificio, Canada
Los Angeles, Cal., 218 East Third St.
Hamilton, Ont., Westaway Bldg.

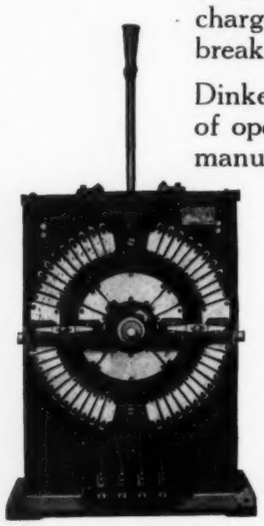
PLANTS LOCATED AT BUFFALO, N. Y., AND ANSONIA, CONN.

# Standing the Gaff



What controller service is more severe than the bridge motion of an open hearth charging machine? Rapid plugging and short moves to line up with the furnace doors, overloads up to the limit of the motor capacity when moving trains of charging box buggies, air laden with metallic dust and dirt to break down weak insulation.

Dinkey Controllers have been recognized by builders and users of open hearth chargers, billet and slab chargers, etc., as the manual controller best able to stand up to this gruelling service.



Dinkey Controller Without Cover

Dinkey Controllers are standard Controllers for hard service on charging machines, soaking pit cranes, stripper cranes, bucket cranes, standard cranes, coke pushers and wherever manual crane type controllers are required that will withstand punishment.

From the standpoint of maintenance, Dinkey Controllers are the cheapest to install.

***D. C. Dinkey Controllers—Bulletin 1000-A***
***A. C. Dinkey Controllers—Bulletin 1002-A***

Dinkey Controller Equipped with Cover

**THE ELECTRIC CONTROLLER & MFG. CO.**

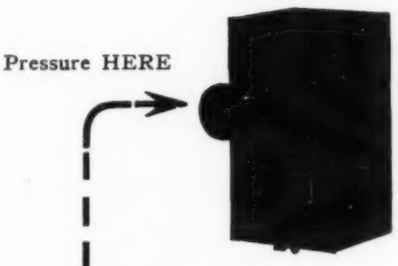
BIRMINGHAM-BROWN-MARX BLDG.
CHICAGO-CONWAY BLDG.
CINCINNATI-1ST NATIONAL BANK BLDG.
DETROIT-DIME BANK BLDG.
NEW YORK-50 CHURCH ST.

**CLEVELAND, OHIO**

LOS ANGELES-THOMAS MACHINERY CO. AMERICAN BANK BLDG.

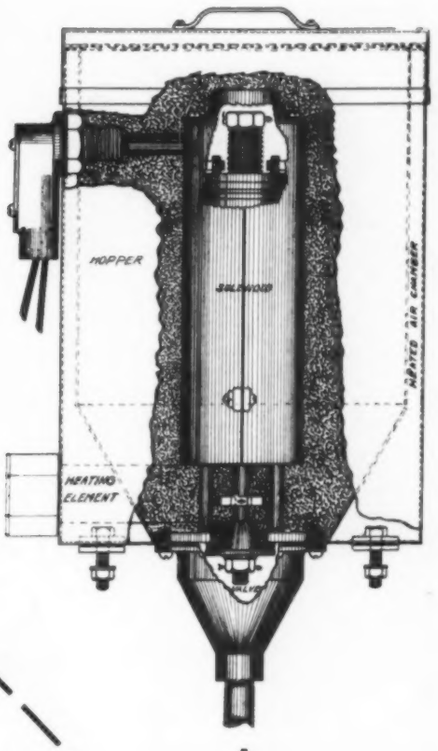
PHILADELPHIA-WITHERSPOON BLDG.
PITTSBURGH-OLIVER BLDG.
SAN FRANCISCO-CALL BUILDING
SEATTLE-570 COLMAN BLDG.
TORONTO-TRADERS BANK BLDG.

# *Give your cranes SAND*




They need it—just as you need it—as your locomotives need it—as your entire organization needs it.

Sand prevents the crane from getting out of alignment and does away with the subsequent strain on crane and runway. It has many other advantages which materially increase the operating and safety efficiency of the crane. All of which you know.




But, the best way to give your crane sand—which you may not know—is with the Lintern Electro Magnetic Sander! Pressure on a button **in the cab** releases sand **immediately.** The operator does not leave the cab, risks no limbs, loses no time.—And the heating element in the sander insures that the sand is in condition for instant response in any weather.

Immediately releases sand HERE, directly on the runway.

**Write For More Detailed Description and Prices!**

## THE NICHOLS-LINTERN CO.

**7960 Lorain Ave., Cleveland, Ohio.**

CANADIAN REP.:

**The Railway & Power Engr. Corp., Ltd.**

**133 Eastern Ave. Toronto, Ont.**

ABSOLUTE ASSURANCE with which operators of Cleveland Cranes handle capacity loads, shows *their* confidence in Cleveland standards of design and construction.

The Cleveland Crane & Engineering Co.
Wickliffe, Ohio

New York
30 Church Street

Pittsburgh
511 Farmer's Bank Bldg.

Chicago
557 Ry. Exchange Bldg.

# CLEVELAND CRANES

# Pittsburgh Transformer Company

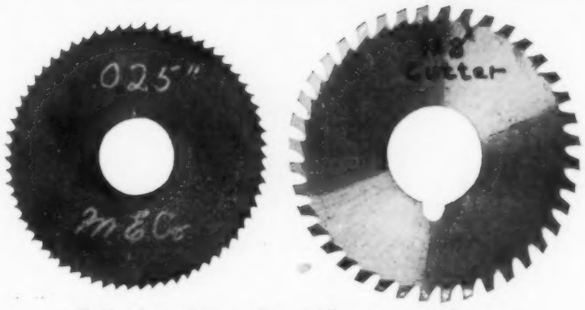
***Largest Manufacturers of Transformers Exclusively in the United States***

**Pittsburgh, Pennsylvania**

## *Introducing the* Martindale Electrical Etcher

This Etching Outfit is for marking gauges, dies, gears, saws, tools, drills, shafting and all other articles made of iron or steel. It is much quicker and more satisfactory than the old paraffine and acid method. Writes like a pencil and burns the letters in the steel making a permanent and legible record.

The Standard Etching Outfit consists of a transformer with three taps, brass contact plate for holding small parts, ground wire and clamp, and hand-piece with four writing points.




Full size views of marking on steel saws

Martindale Electric Co.

11730 Detroit Ave., Cleveland, O.

Please send me literature on your new Electrical Etcher.

Name and Title.....
(Please print)

Company .....

Street and No.....

City and State.....

# ALLIANCE CRANES

***Largest Builders of the World's Largest Cranes***

**213 of 100 Tons Capacity and Over**

LADLE AND STANDARD CRANES

| | | |
|---|---|---|
| 58 | 100 | tons |
| 2 | 115 | tons |
| 44 | 125 | tons |
| 25 | 150 | tons |
| 24 | 175 | tons |
| 2 | 200 | tons |
| 1 | 225 | tons |
| 1 | 250 | tons |
| 3 | 430 | tons |

STRIPPING CRANES

| | | |
|---|---|---|
| 8 | 100 | tons |
| 1 | 125 | tons |
| 20 | 150 | tons |
| 13 | 200 | tons |
| 1 | Single Ram, 320 | tons |

COMBINATION CHARGERS AND STRIPPERS

| | | |
|---|---|---|
| 3 | 100 | tons |
| 3 | 150 | tons |
| 4 | 200 | tons |

# INDUSTRIAL PLANT AND FACTORY EQUIPMENT

*IMMEDIATE DELIVERIES*

Benjamin Reflectors and Howlers
Buss Renewable Fuses
Square-D Switches
Ilg Blowers and Ventilating Fans
Triumph Motors and Generators
American Steel & Wire Co. Wires and Cables
Unilets and Reelites

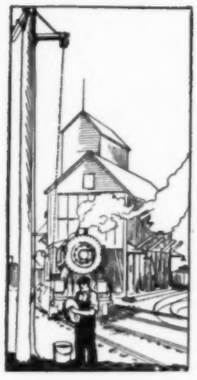
# DOUBLEDAY-HILL ELECTRIC CO

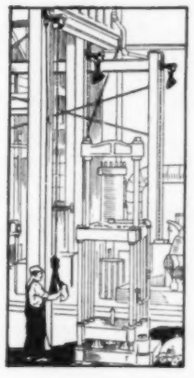
719-21 LIBERTY AVENUE PITTSBURGH, PA.

THOMPSON
SAFETY *Lowering* SWITCH
*~or Disconnecting Hanger*

# *A Convenience—or a Necessity?*

## Where do you draw the line?

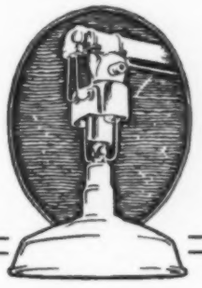




A Convenience—in the Industries—usually facilitates production and promotes safety—two of the most important factors in efficiency and the development of a successful business. Who then is going to draw the line between a convenience and a necessity, and where?

The Thompson Safety Lowering Switch solves the lamp-cleaning problem, because it enables the work to be done with ease and safety down on the ground—no climbing hazards—no electrical hazards, for the lamp is lowered away from the electric circuit for the cleaning process. Obviously the work will be more likely to be done.

***Send for Catalog B-25 for interesting details.***



**The Thompson Electric Co.**

**1438 W. 9th St.** **Cleveland, Ohio**

# Armature & Field Coils

## Special Attention to Steel Plants
## Materials of Proven Quality Used

*Prompt and Efficient Deliveries~*

## Strap Coils Reinsulated • Molds and Shaping Machines of all Descriptions

## Our Prices Compete

# DOUBLEDAY-HILL ELECTRIC CO

**Winding and Repair Dept.** **719-21 Liberty Ave., Pittsburgh**

# Kangri

is the disease that the native of Kashmir contracts as a result of wearing a box containing hot embers strapped to his belly in winter time.

You see the box doesn't produce an even warmth, simply heats him up in spots—then kangri sets in at those spots as nature's kick against the practice, just as burned spots on a commutator represent the natural kick against a mischosen or misapplied carbon brush.

It is the duty of all Morganite engineers to preclude the possibility of commutator kangri by studying the needs of the service and prescribing the right grade of Morganite brush to deliver uninterrupted commutation.

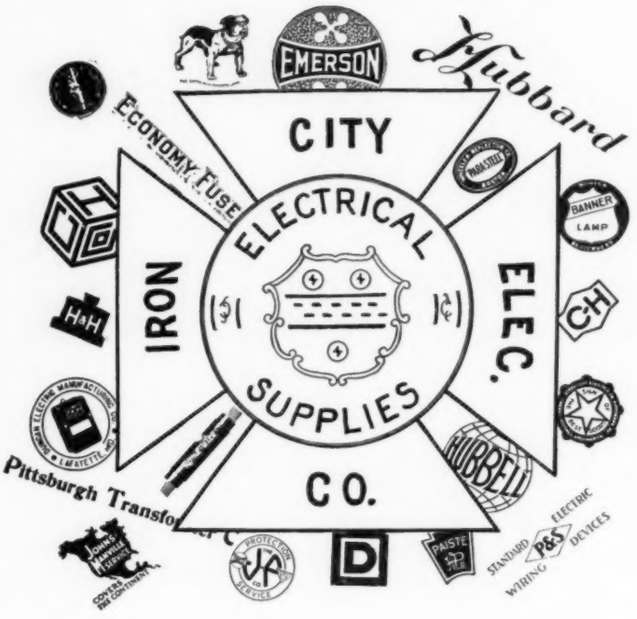
"But that character of service will cost me a lot of money," you say.

NO, SIR!! Emphatically No.

It saves you money and your satisfaction at the economy is our best advertisement.

**Morganite**

O. T. Hall, Sales Engineer, 1926 Edmonson Ave., Baltimore, Md.
Electrical Engineering & Mfg. Co., 909 Penn Ave., Pittsburgh, Pa
Electrical Engineering & Mfg. Co., 422 Union Bldg., Cleveland, Ohio.
Electrical Engineering & Mfg. Co., 607 Mercantile Library Bldg., Cincinnati, Ohio.
Special Service Sales Co., 502 Delta Bldg., Los Angeles, Calif.
Special Service Sales Co., 202 Russ Bldg., San Francisco, Calif.
J. F. Drummey, 75 Pleasant St., Revere, Mass.
Railway & Power Engineering Corp., Ltd., 131 Eastern Ave., Toronto, Ontario, Canada.
Railway & Power Engineering Corp., Ltd., 826 Craig St., West, Montreal, Canada.
Railway & Power Engineering Corp., Ltd., P. O. Box No. 325, Winnipeg, Canada.




The Trade Mark

of the

# Iron City Electric Co.

436-38 Seventh Avenue

## Pittsburgh, Pa.

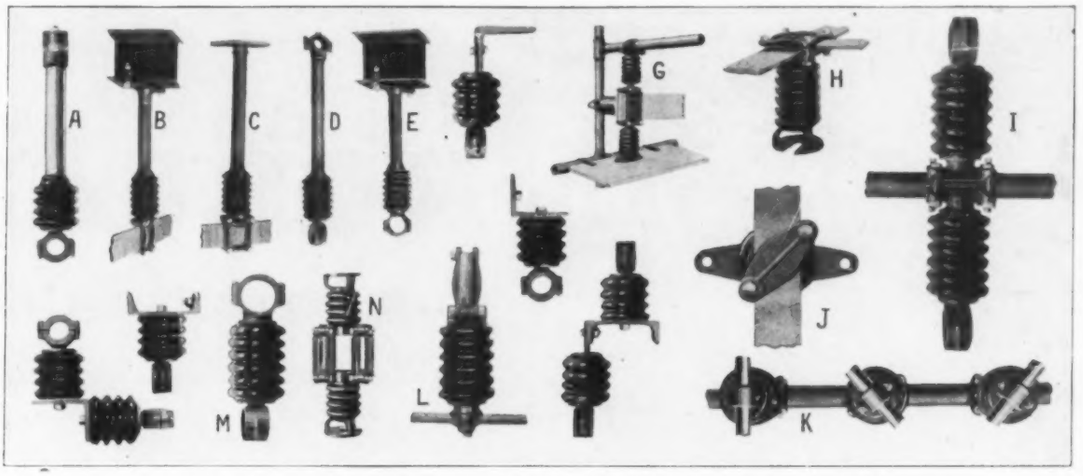
REPRESENTING

*"The House That Service Built"*

IS BACKED BY A GROUP OF

TRADE MARKS

Of Well Known Manufacturers Guaranteeing the Quality of the Goods You Receive



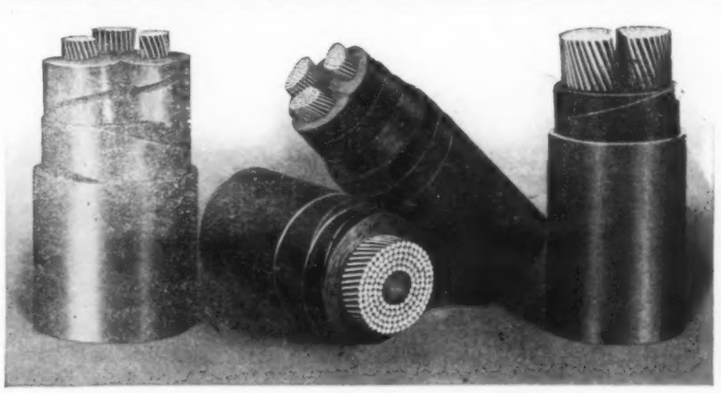

Just a Few of Many Thousand Applications of Unit Type Bus Support Fittings

Figures "A" to "E" inclusive illustrate methods of using the pipe extension fittings, enabling the bus to be maintained at a definite level.

Figure "G" shows a three-way support; Fig. "H" a tap off; Fig. "I" a neat arrangement for vertical conductors to oil switches and buses; Fig. "J" illustrates methods of turning clamp to fit smaller conductor; Fig. "K" illustrates adjustable features permitting bus to be run at any angle; Figs. "L" and "M" show method of supporting a tap line to a bus from an adjacent bus without installing additional structure; Fig. "N," a method of spreading conductors of the same phase. The balance show various convenient mounting methods. There are thousands of combinations possible with Unit Type fittings. Ask for Bulletin 31-B.

*"Unit Type"* **Delta-Star Electric Co** *"Unit Type"*

**2400 Block, Fulton St., Chicago, Illinois**



YOUR every requirement in the way of electric wires and cables can be fully met from the complete and highly developed STANDARD line.

Four large, completely equipped STANDARD factories at convenient distribution centers afford exceptional manufacturing and shipping facilities.

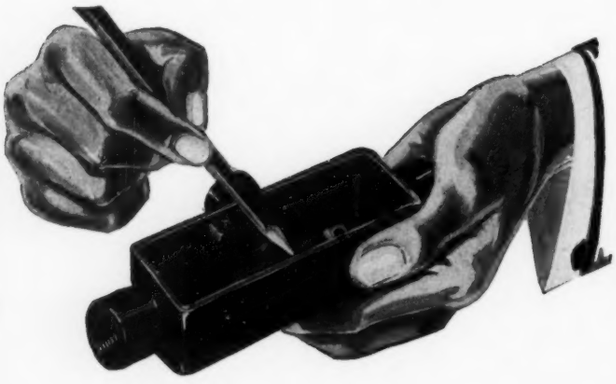
Over 43 years devoted exclusively to the manufacture and installation of STANDARD Products gives us a wealth of experience which is at the service of our customers.

*We will appreciate an opportunity to serve you.*

**Standard Underground Cable Co.**

General Offices: Pittsburgh, Pa.

BOSTON WASHINGTON CHICAGO KANSAS CITY NEW YORK ATLANTA DETROIT
SEATTLE PHILADELPHIA PITTSBURGH ST. LOUIS LOS ANGELES SAN FRANCISCO
FOR CANADA: STANDARD UNDERGROUND CABLE CO., OF CANADA, LIMITED, HAMILTON, ONT.



# 50% more working space

ONE of the reasons why Appleton Unilets reduce costs is because they have 50% more working space.

They are smooth. There are no rough edges to cut the wire. Clean, firm connections are quickly made. Their flat bottoms permit them to be securely fitted against wall or ceiling without special work.

Workmen like to install Appleton Unilets because the installation is good-looking and easy to make.

When Appleton Unilets are a part of the job the conduit goes in quickly, without delay because they are made in hundreds of different styles to fit every wiring need.

Send for Catalog 9-D. Appleton Unilets and fittings can be procured everywhere without wait or delay.

Type "A"
Rectangular Unilet with Three-Wire Porcelain Cover

Type "C"
Rectangular Unilet with Rectangular Porcelain Receptacle

Type "LL"
Rectangular Unilet with Blank Metal Cover

**APPLETON ELECTRIC CO.**
**1717 Wellington Ave.**
**CHICAGO**
New York: 265 Canal Street
Los Angeles: 340 Azusa Street

APPLETON
STANDARD FOR BETTER WIRING
UNILETS



1891 — 1925

# MORGAN
## Construction Co.

Worcester, Mass., U. S. A.

*Designers and Builders of*

## Morgan Continuous Mills

*for*

Billets, Sheet Bars, Skelp, Merchant-Bars, Hot-Strip, Rods

*also*

**Wire Drawing Machines**
**Producer Gas Machines**
**Straightening Machines**
**Isley Reversing Valves**
**Re-Heating Furnaces**
**Reducing Gear Units**
**Shears**

---

## *Our Engineering Department*

is prepared to solve successfully your problems in design or arrangement of plant and equipment from open hearth to finished product

1891 — 1925

# Salamander

## *W. E. Finish*

Asbestos Insulated Magnet Wire is superior in its dielectric properties to other types of Asbestos Insulated Magnet Wire now manufactured. By removing the molecular moisture contained in the fibre at a temperature that would carbonize cotton, and substituting a moisture proof compound, the W. E. Finished Salamander Magnet Wire has a smooth, hard, heat-resisting oil-proof and acid-proof finish which is extremely tough, resembling raw hide.

# York Insulated Wire Works

***of General Electric Co.***

**WORKS: YORK, PA.**

**120 Broadway, New York, N. Y.**



# ROLLER-SMITH

## TYPE GSD VOLT-AMMETER

**A combination instrument that you cannot afford to be without**

For the plant that wants trustworthy testing instruments at the lowest possible cost—this ROLLER-SMITH Type GSD direct current Volt-ammeter is of inestimable value. For all around general service in factories, laboratories and educational institutions this instrument is unsurpassed.

The ROLLER-SMITH GSD instruments are recognized in every industry as much needed aids to efficiency. This GSD Volt-ammeter is a real combination portable D.C. Volt-ammeter that takes up the space of only one instrument and yet costs much less than two separate instruments. Of convenient size, light-weight, rugged and—above all—accurate and reliable, it does double the work—for only a little more than half the investment.

Ranges up to 750 amperes and 750 volts in all sorts of combinations.

The Type GSD Volt-ammeter and other Type GSD instruments are fully described and listed in Bulletin AK-210.

Your copy is ready for you. Use the coupon.

"Over thirty years' experience is back of ROLLER-SMITH."

**ROLLER-SMITH COMPANY**

Electrical Measuring and Protective Apparatus

**Main Office:**
**2131 Woolworth Bldg., NEW YORK**

**Works:**
**Bethlehem, Penna.**

| | | | |
|---|---|---|---|
| Atlanta | Cleveland | Memphis | Salt Lake City |
| Baltimore | Dallas | Montreal | San Francisco |
| Bethlehem | Denver | New Haven | Seattle |
| Birmingham | Detroit | New Orleans | St. Louis |
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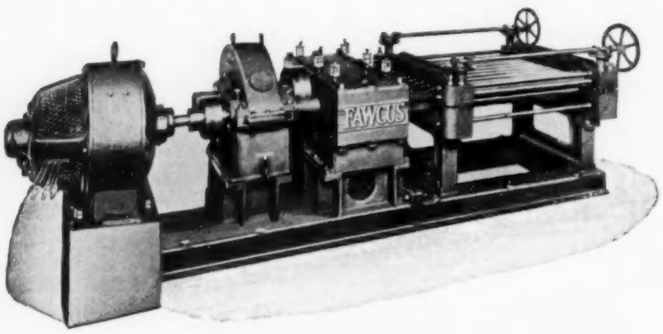
Request for Roller-Smith Bulletin AK-210

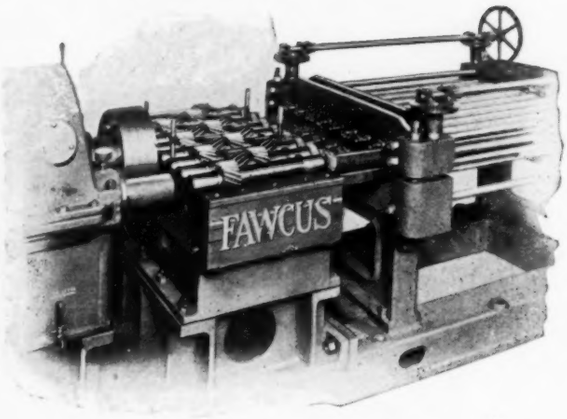
Name .....

Address .....

Company .....

City ..... State .....




Gear Box for Driving Rollers

# FAWCUS
## Sheet Roller Leveler

Designed for the production of an improved product in cold rolling sheets. The use of Fawcus Herringbone Gears throughout eliminates all vibration and gives a steady, uniform velocity to the rolls, overcoming the marking of sheets, and producing a perfect sheet without buckles, waves or riffles.

The same type of lever has been developed for strip mill product with shorter rolls and lighter construction, but of the same general design. This machine can be built with the entering rolls adjustable also, while in the machine illustrated the last roll only has independent adjustment.

## FAWCUS MACHINE CO.
### PITTSBURGH, PA.

REPRESENTATIVES

NEW YORK, N. Y.
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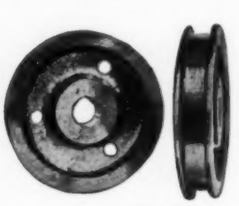
PORTLAND, ORE.
Coast Steel Machinery Co.

NEW ORLEANS, LA.
Southern Jobbers Supply Co.

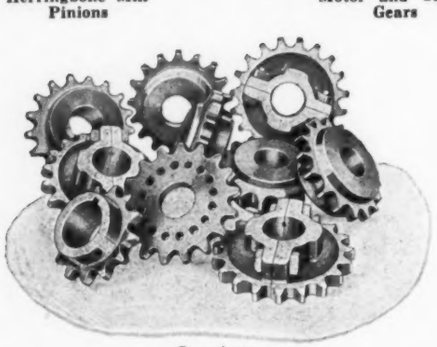
Herringbone Mill Pinions

Motor and Crane Gears

Mill Table Gears



Crane Wheels



Sprockets

"Tool Steel" sprockets
run and run
and keep on running without wear.

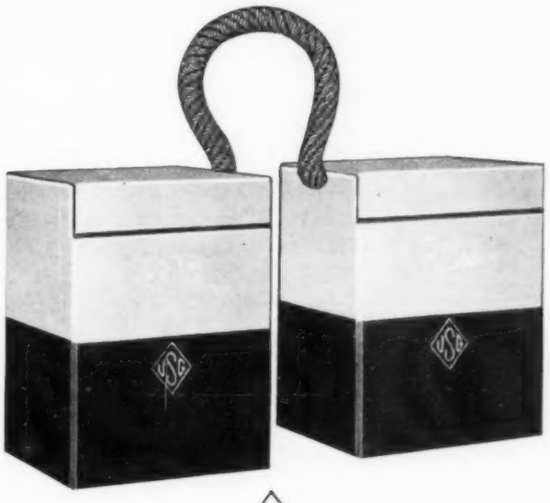
Mill Coupling Box

Herringbone Gears

Spur Mill Pinions

# The Tool Steel Gear and Pinion Company
## CINCINNATI, OHIO

Cement Mill Gearing



*on every brush*

# No More Chipped or Broken Controller Contacts

Many Steel Mill Electricians have overcome the curse of broken and chipped controller contacts by always specifying and insisting on

## CONTACTS

***Why Don't You?***

The fine, close-grained carbon-graphite composition of U. S. G. Contacts, insures exceptionally long wear with but a minimum of care.

Let your next set be U. S. G. and notice the difference.

## The United States Graphite Company

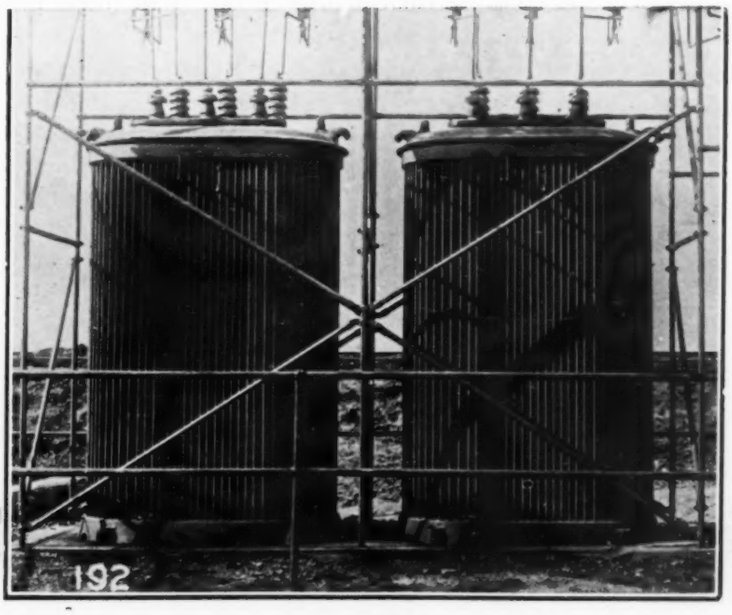
**Saginaw, Michigan, U. S. A.**

District Offices

New York Philadelphia Pittsburgh Chicago St. Louis San Francisco

# Moloney Transformers

***Exceptional daily performance testifies to Moloney superiority***



There is, after all, only one way to judge the actual worth of a transformer and that is its record of service under various conditions. Moloney Transformers have continuously lived up to every claim we have advanced, they have rendered the kind of service that gains the complete approval of users. Moloney Transformers can be had in all types and sizes from the small distribution unit to the larger power sizes.

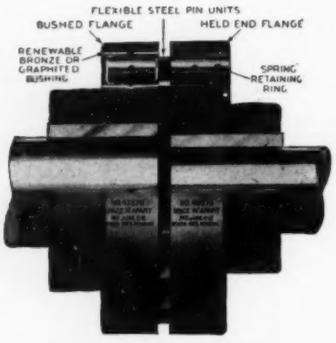
**Moloney Electric Co.**
**St. Louis, Mo.**

*The New, Improved*

**FRANCKE**
FLEXIBLE COUPLINGS

*Effective Dec. 1, 1925*

*For Motor, Turbine, Engine Drives*




**Bushed Pin Type**

**Graphited Bronze Bushings** in Size No. 850 and larger (bronze bushings in smaller sizes) are removably locked in one flange. The steel pin units are free to slide a full half inch within these bushings. Contact surfaces are more than doubled; a cylindrical surface is obtained; movement is between steel and bronze; and the graphited bushings present a **self-lubricated** surface that retains its lubricating qualities for many years.

**The improved Francke Coupling** retains the best features of the old Heavy Pattern Type and adds several new features to make a better coupling. More and easier endwise movement. Greater power and bore capacities. Much longer life for all speeds. Steel flanges for small and intermediate sizes.

**The Francke handles all accidental misalignments**—Out of center, in an angular direction and endwise; cushions starting and load shocks; absorbs vibrations; runs in either direction; is noiseless.

**In case of excessive misalignment** it acts as a safety device, saving broken or scored shafts, bearing troubles, etc. However, if more than the usual misalignments are expected, due to non-rigid foundations or for any other reason, two couplings in tandem with an intermediate shaft or a Double Floating-Ring Type Francke Coupling should be used.

**Other Francke Features.** Easily mounted, aligned and connected without special tools. All metal, no perishable material. No movement or wear on shaft flanges to cause expensive renewal of complete coupling. Simple and safe.

***Ask for Bulletin 37 S.***

**SMITH & SERRELL**

Coupling Specialists Since 1912.

**64 Washington Street, Newark, N. J.**

**District Engineers at Pittsburgh, Cleveland, Chicago**

**RUMSEY**

**ELECTRIC COMPANY**

***Electric Supplies & Machinery***

***Everything in Radio***

**1007 Arch St.**

**Philadelphia, Pa.**

**DISTRIBUTORS OF**

**Pittsburgh Transformers**
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**Faraday Bells and Buzzers**
**Eveready Flashlights**
**Insulating Tape**

*Bulletin 26 describes the complete line of Baker tractors, trucks and cranes.*

# *When Experience Counts Most*

Standard Baker tractors, trucks and cranes cover the ordinary range of material-handling requirements in every industry.

This special 6 ton Hy-Lift, built for the steadily increasing size of parts and dies in the automobile industry, illustrates how well fitted this organization is to cope with unusual demands.

THE BAKER R & L CO., Cleveland, Ohio

ELECTRIC TRACTORS AND TRUCKS

TRADE-MARK REG. U.S.PAT.OFF.

**Baker**

**HUESSENER Combustion Control responsible for another Open Hearth Production Record.**

**The TRUMBULL STEEL CO'S. No. 6 Open Hearth furnace completed recently the longest campaign on record, making—**

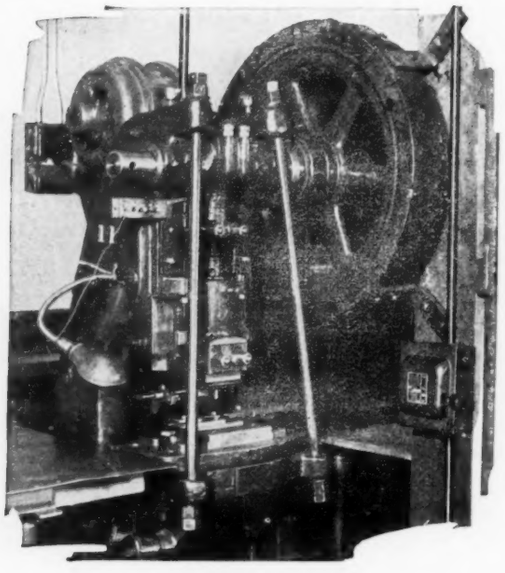
**42,334 tons in a run of 409 heats on the same roof, using exclusively coke oven gas as fuel.**

**We have also a first Steinbart control for producer gas fired open hearth furnaces in successful operation at the same works.**

***Write for full particulars to—***

**AMERICAN HEAT ECONOMY BUREAU Inc.**
**926-930 Wabash Bldg., Pittsburgh, Pa.**

**English Address—International Heat Economy Bureau, Ltd., Brook House, Walbrook, London E. C. 4, England.**



# "CIRCLE T" TRUMBULL "R.M." TYPE Full Safety Switches

**This is the day of individual drive which means individual control.**

**Cut shows a "Circle T" "R. M." type two position motor starting switch used on a power press.**

**"R. M." switches are small in size, low in price, with full type "A" electrical and mechanical strength.**

**Three types for use with motors up to 7½ H. P. at 440-550 Volts.**

**1. 2-position—short circuits fuses in starting.**

**2. With time limit protective cutouts.**

**3. Fusible.**

**Circular No. 2 fully describes each of these switches as well as our mailed clip line.**

## THE TRUMBULL ELECTRIC MFG. COMPANY

Plainville, Conn.

NEW YORK
114 Liberty St.

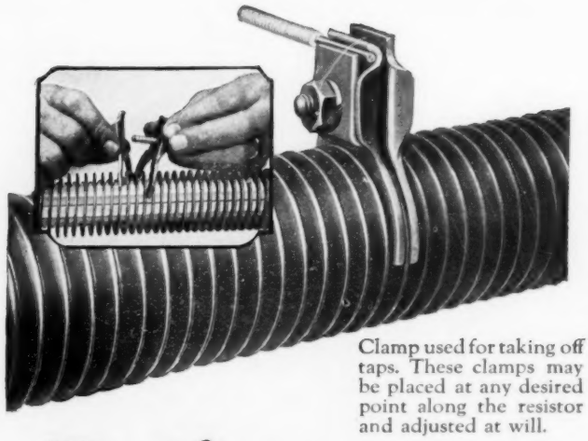
SAN FRANCISCO
595 Mission St.

CHICAGO
2001 W. Pershing Road

PHILADELPHIA

BOSTON

JACKSONVILLE, FLA.



Clamp used for taking off taps. These clamps may be placed at any desired point along the resistor and adjusted at will.

# Perfect taper *and adjustable too!*

TAPS may be placed at any point on the helical winding of Monitor Edgewound Resistors and moved at will, thus enabling the resistance steps to be tapered accurately in any desired manner.

A simple form of clamp is used for the purpose of taking off taps, the same form of clamp being used for terminal connections. Another form of clamp, with facilities for taking off a tap, is used for joining adjacent units together.

Both forms of clamps take a powerful and fast grip on the ribbon, giving an almost perfect electrical connection which will not work loose in service.

There are many other advantageous features of the Monitor Edgewound Resistor in which you will be interested — in fact, it beats cast-iron on every count. Ask for Bulletin 107 which describes the Monitor Edgewound Resistor in detail.

## Monitor Controller Company

Baltimore, Maryland

Boston
Buffalo
Chicago
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Cleveland

The Original "Just Press a Button" System

Washington

Detroit
New Orleans
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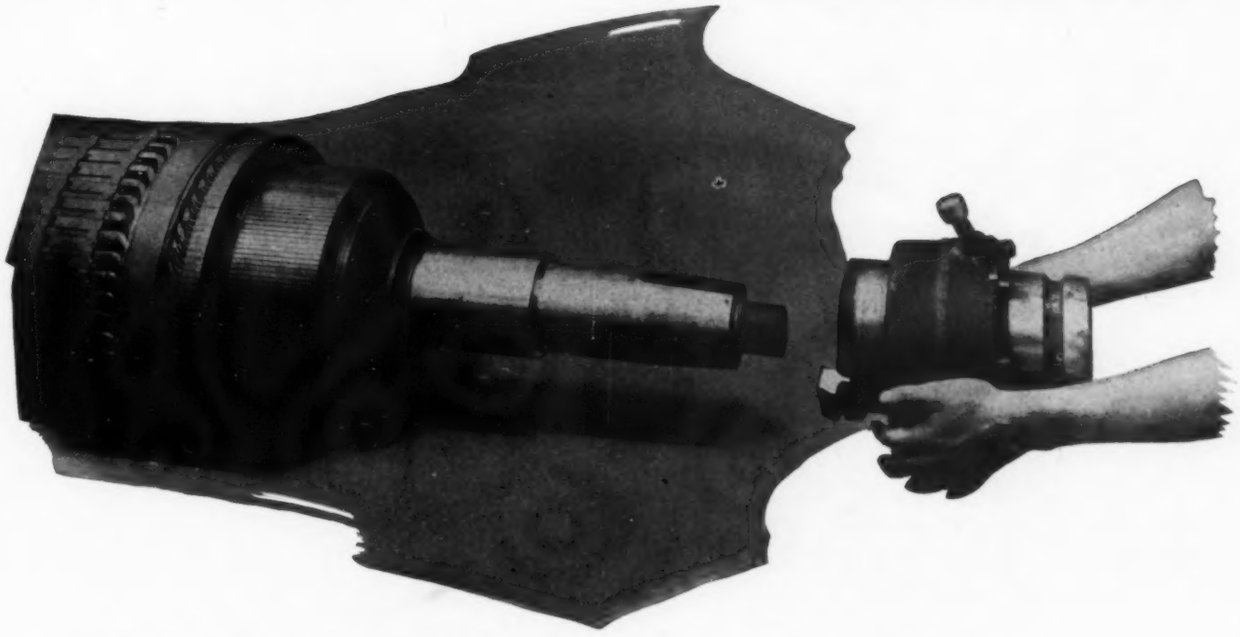
Pittsburgh

6710-6A

# Monitor Edgewound Resistor



# The Boys Who Do the Work Know *They're Easy to Install*

ANY steel mill electrical man who has changed over a motor from plain to Hyatt roller bearings knows how easy it is.

For Hyatt bearings are furnished complete with steel housings, which are interchangeable with brass on most sizes of mill and crane motors.

These may be applied to existing motors in the steel plant or to new motors furnished by the manufacturer.

Many types of motors require no changes either to motor frame or armature shaft.

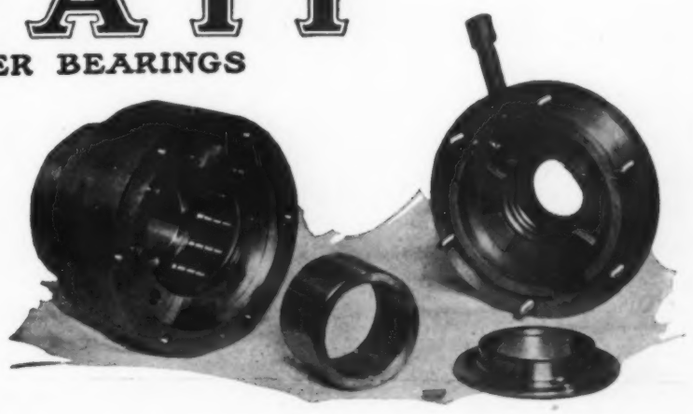
A large percentage of heavy duty electric motor failures is traceable to bearing trouble. That is why steel mills are changing over to dependable Hyatt roller bearings.

Hyatt bearings keep your motors out of the repair shop. They keep them running free from the failures caused directly or indirectly by sleeve bearings. Our engineers will gladly furnish any information desired on this application.

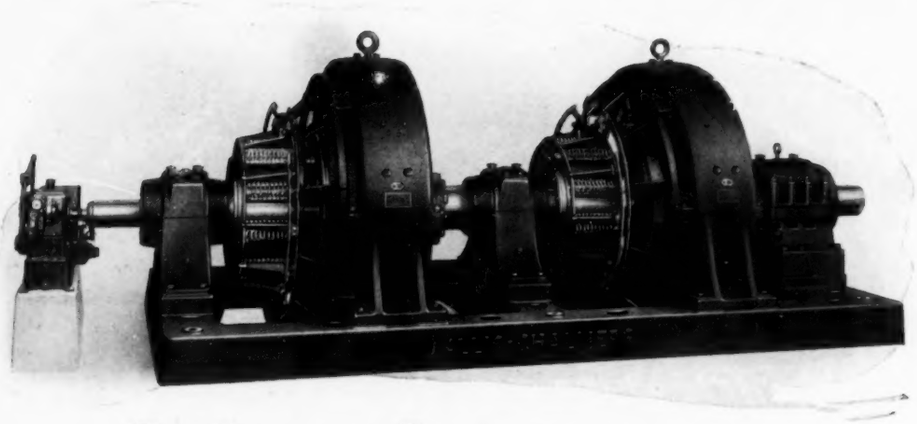
HYATT ROLLER BEARING COMPANY
NEWARK, N. J.

**HYATT**
**ROLLER BEARINGS**

*Disassembled view of Hyatt roller bearing housing for electric motors. Their installation is an assurance of steady, dependable motor operation.*



# ALLIS-CHALMERS



$\frac{1000}{2000}$ h.p. $\frac{200}{400}$ r.p.m. 2000 h.p. $\frac{400}{600}$ r.p.m. 250 Volt Direct Current Motor.

**Frog-Leg Wound Direct Current Motor built for close speed regulation from 200 to 600 r.p.m**

**The Frog-Leg winding insures perfect commutation under all conditions of load.**

**PRODUCTS:**

Electrical Machinery
Gas Engines
Steam Engines
Steam Turbines
Condensers
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Flour Mill Machinery
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Air Brakes
Steam and Electric Hoists
Farm Tractors
Power Transmission Machinery

ALLIS-CHALMERS MANUFACTURING CO.
MILWAUKEE, WIS. U.S.A.

# Simplifying Motor Operation

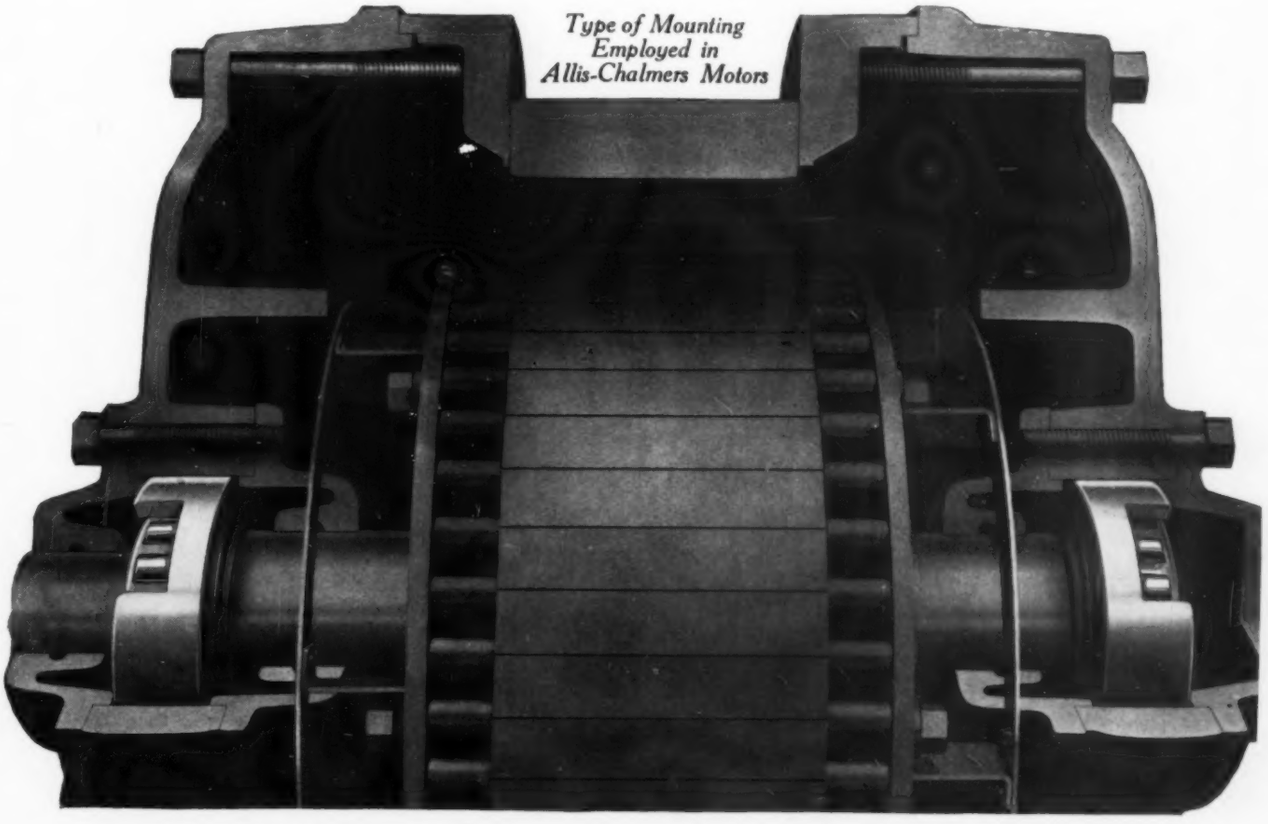
The air gap is permanently fixed in electric motors which have the rotor mounted on Timken Tapered Roller Bearings.

The Timken-made steel in Timken Bearings, the rolling motion, the inherent self-aligning properties of Timken rolls, and the ease of lubricating Timkens perfectly, are guarantees of long motor life.

Since Timken design also provides greater load area for space required, shaft rigidity is increased, compactness is gained, and drive layouts are improved. Every form of drive and any motor mounting works equally well because Timken Bearings carry radial and thrust loads equally well.

Here is insurance against motor troubles and shutdowns, obtained with a very minimum of inspection, and with lubrication at rare intervals only. Add the savings in current, starting and running, and you know why great industries will no longer do without Timken-equipped electric motors.

THE TIMKEN ROLLER BEARING CO.
*C A N T O N , O H I O*



*Type of Mounting Employed in Allis-Chalmers Motors*

**TIMKEN** *Tapered Roller* **BEARINGS**

# OHIO Magnets

are particularly well suited to perform the work of magnetic separation of tramp iron from material that is to be crushed or from which, for other reasons, the tramp iron must be removed.

They have all asbestos insulation which is not affected by the heat of continuous operation and they are wound to carry current continuously so do not require any external resistance.

Note suspension on jib crane so magnet can be swung around to discharge its accumulated load. Also note it is hung over the pulley where the stream of material will be flatter and much broken up, thus favoring complete removal of tramp iron.

## *The* Ohio Electric and Controller Co.

*Cleveland, Ohio*

*ASK US OR OUR REPRESENTATIVE*

G. H. Armstrong, 605 First National Bank Bldg., Cincinnati, O.
J. W. Ogden, 406 So. Franklin St., Syracuse, N. Y.
K. I. Clisby, Woolworth Bldg., New York City, N. Y.
Claude H. Cooper, Houghton, Mich.
Joy & Cox, Inc., 211 Tramway Bldg., Denver, Colo.
J. B. Howard, 398 Newbury St., Boston, Mass.
Holden Company, Ltd., Montreal, Toronto, Winnipeg, Vancouver, B. C., for Canada.
G. R. Horne, 2254 Penobscot Bldg., Detroit, Mich.
Jennings McCollum, 407 Dooly Bldg., Salt Lake City, Utah.
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G. H. Maire, 95 Connecticut St., Seattle, Wash.
Charles J. Mundo, 241 Union Trust Bldg., Pittsburgh, Pa.
Linn O. Morrow, 811 Schaff Bldg., Philadelphia, Pa.
Nixon-Hassele Co., Chattanooga, Tenn.
L. J. Smith, 324 N. San Pedro St., Los Angeles, Calif.
Southern Industrial Engineering Co., Birmingham, Ala.
C. H. Stem, Audubon Bldg., New Orleans, La.
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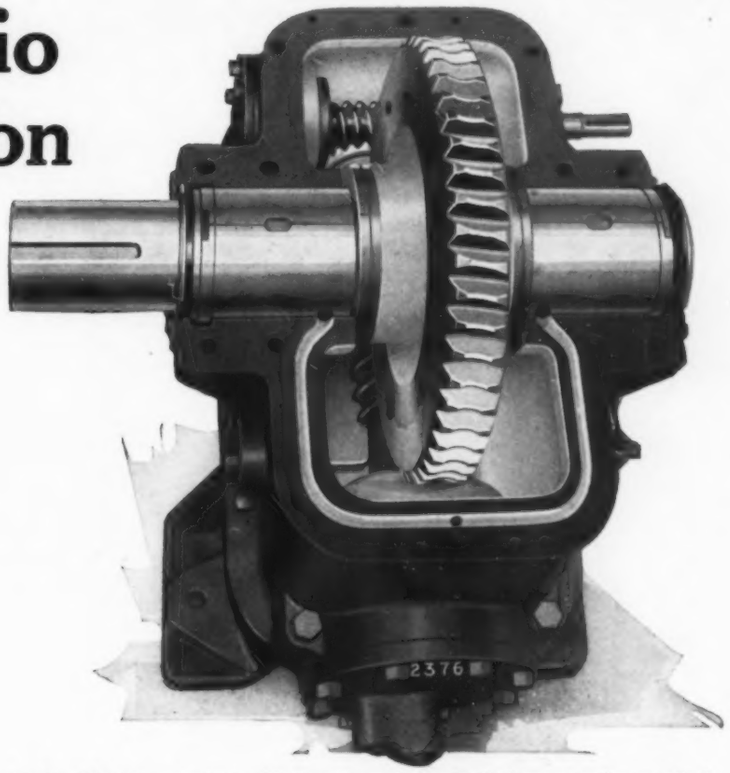
R. E. Bock, 53 West Jackson Blvd., Chicago, Ill.

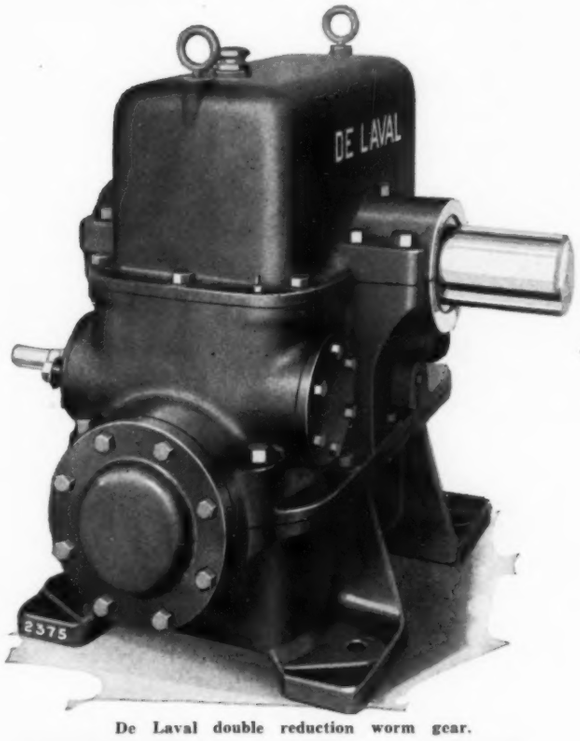
# For High Ratio Speed Reduction

**As Required for Cooling Tables, Conveyors, Heat Treating Furnaces, Stokers and Similarly Slow Moving Machinery.**

## Use the De Laval Double Reduction Worm Gear




Double reduction worm gear with cover removed, showing both worms and worm wheels.




De Laval double reduction worm gear.

**RATIOS up to 100 to 1 are provided by De Laval Single Reduction Worm Gears, while De Laval Double Reduction Gears take care of all higher ratios, up to 10,000 to 1.**

**The De Laval Double Reduction Worm Gear contains, exclusive of shaft bearings, only three working members, the high speed worm, the high speed wheel mounted upon the slow speed worm, and the slow speed wheel and shaft. All gear contacts and bearings are immersed in the lubricant, with the exception of the slow speed shaft bearings, which receive positive lubrication from an oil pump within the case.**

**The whole reduction is enclosed within, and supported by, a rigid casing, which also serves as an oil well. The only attention required is to change the oil at long intervals. Ask for Catalog R 150.**

# De Laval Steam Turbine Co., Trenton, N.J.

**Local Offices:** Atlanta, Boston, Charlotte, Chicago, Cleveland, Dallas, Denver, Duluth, Helena, Houston, Indianapolis, Kansas City, Los Angeles, Montreal, New Orleans, New York, Philadelphia, Portland, Ore., Pittsburgh, St. Paul, Salt Lake City, San Francisco, Seattle, Spokane, Toronto, Vancouver.

Manufacturers of Steam Turbines, Centrifugal Pumps, Centrifugal Blowers and Compressors, Double Helical Speed Reducing Gears, Worm Gears, Hydraulic Turbines, Flexible Couplings and Special Centrifugal Machinery

490

# Paid for Itself in 10 Months

This Static Condenser installation paid for itself in ten months, and now saves the owner $165.00 each month on his power bill.

Westinghouse static condensers may be installed in locations not suitable for manufacturing purposes, such as platforms, cellars, unheated sheds, or on balconies suspended from the ceiling.

When indoor space cannot be provided, a complete line of outdoor equipments is available for pole or ground mounting.

For more complete data, ask for copies of Circular 1670 and Leaflet 20044-B.

Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of the United States and Foreign Countries

# Westinghouse

X 85593

Yards of one of the large steel companies, illuminated by Pyle-O-Lytes. Two type No. 2360 Pyle-O-Lytes are mounted on a steel tower at the head of the yard.

# Increase the Night Shift's Production

BRILLIANT, evenly distributed light is just as much of an essential factor here as power to move the materials. With Pyle-O-Lytes a convenient, economical and satisfactory installation is a simple matter, for these powerful flood-lights are designed for just this class of service.

Two 23 inch Pyle-O-Lytes furnish the illumination shown in the night view above. They are mounted on a 35 foot steel tower, and Pyle-National rectangular divergence lenses provide the spread beam to cover the entire working area with light.

Send for bulletins describing the new 23 inch Pyle-O-Lyte which has just been announced.

## The Pyle-National Company

General Offices and Works

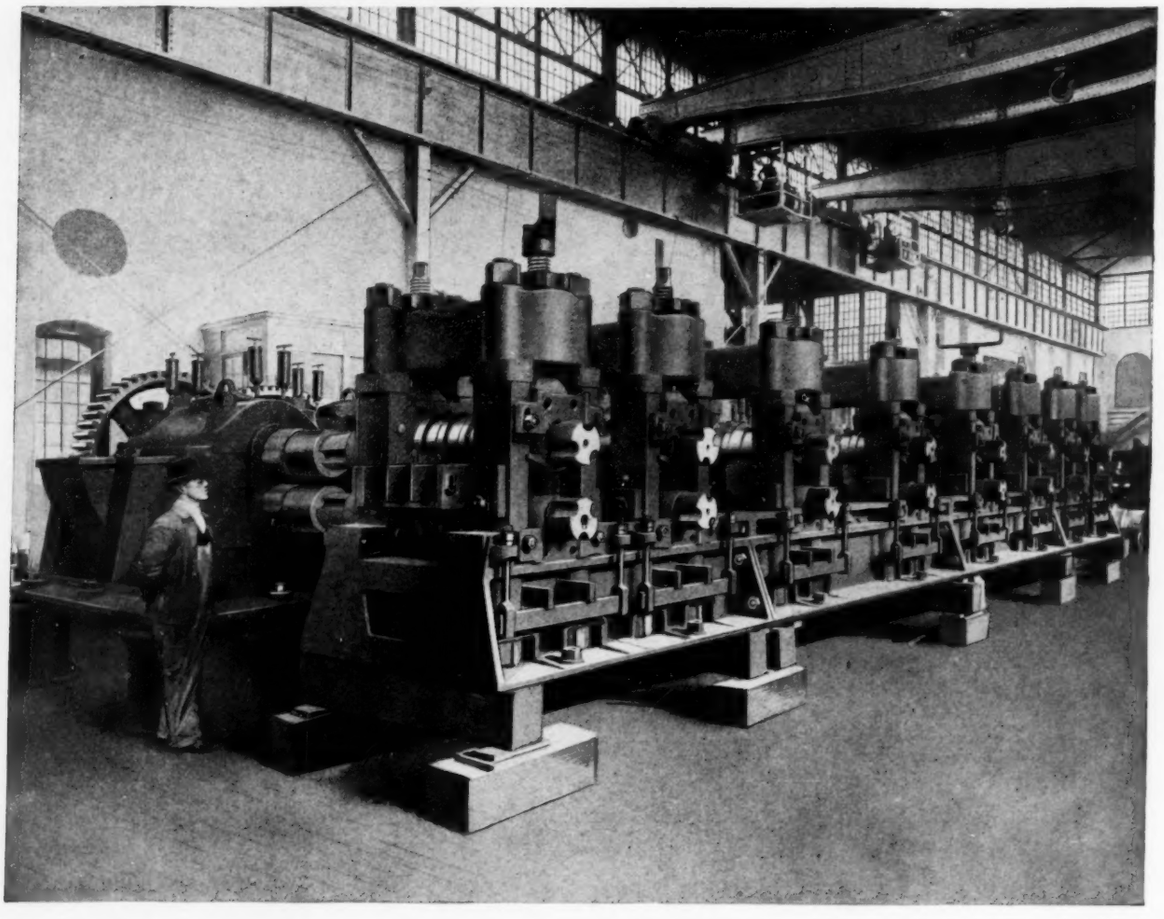
**1334-1358 N. Kostner Ave., Chicago, Ill., U. S. A.**

Canadian Agents: The Holden Company, Ltd.
Montreal, Winnipeg, Vancouver, Toronto.

Trademark Registered

Export Department: International Railway Supply Company
30 Church Street
New York City

# MORGAN



## 14″ Continuous Roughing Mill

*Designed and Built for the Imperial Steel Works, Japan*

Mill is composed of eight stands, and driven through a train of spur gears with cut teeth. Gears are entirely enclosed. Reducing gears and mill pinions are contained in one housing. Mill housings are constructed of forged steel slabs.

The entire installation includes Roughing Mill, Belgian Loop Mill with Rope Drive, Feed Tables, Chutes, Floor Plates, Reels, Bundle Conveyor, etc.

**The experience of Morgan Engineers combined with the unusual production facilities of the Morgan plant, permit construction and installation of steel mill equipment units of remarkable efficiency.**

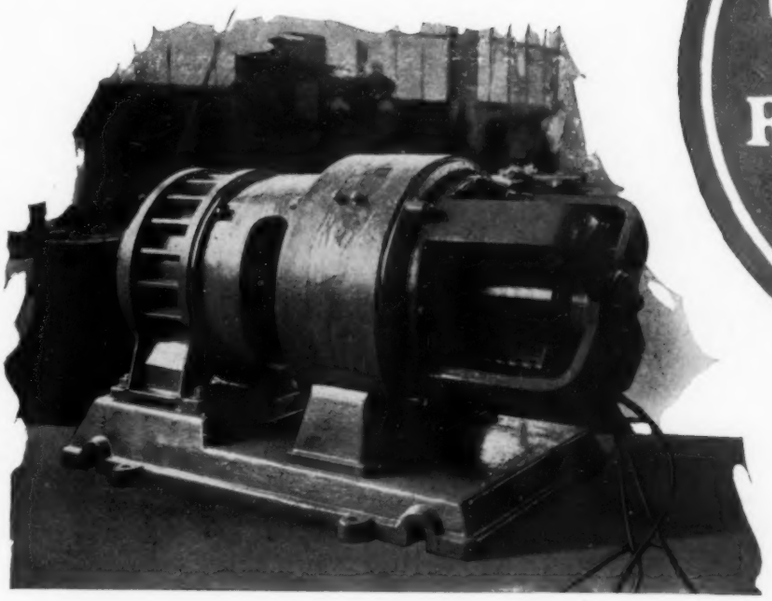
**Many steel plant executives know this truth—***"If Morgan builds it—it's built right."*

**The Morgan Engineering Company**
**Alliance, Ohio, U. S. A.**

CHICAGO: 1422 So. Michigan Ave.
PITTSBURGH: 1420 Oliver Bldg.
NEW YORK: 120 Broadway

**Designers, Manufacturers and Contractors Electric Traveling Cranes, Rolling Mill Machinery, Steel, Forging Plants. Complete Rock Crushers, Special Machinery for Any Purpose, Locomotive Repairing and Rebuilding, Fabricated Structural Steel.**

"KEEP ARMATURES STEADY, EFFICIENT AND READY"



SKF
Puts the Right Bearing in the Right Place

SKF is linked with a world-wide reputation for delivering satisfactory service, and to an investment too large to be jeopardized by non-performance of anything with which it is connected.

Therefore SKF provides a supervision of factories throughout the world and an international organization for scientific research in engineering, manufacturing and merchandising to assure to the user a full measure of performance in products endorsed with the mark SKF.

## Smooth Operation—Low Maintenance Feature of SKF-Equipped Motors and Generators

THERE'S no danger of the armature or rotor on this large motor-generator dropping and striking pole pieces. Three SKF-marked Anti-Friction Bearings insure smooth, easy running and maintain original operating efficiency for years.

Bearing wear and oil leakage, two of the most prolific causes of motor trouble, are eliminated. SKF-marked Anti-Friction Bearings have been widely adopted on motors from fractional horsepower to those used in steel mills throughout the world.

1492

SKF INDUSTRIES, INCORPORATED — 165 BROADWAY — NEW YORK CITY

ATLANTA, BOSTON, BUFFALO, CHARLOTTE, CHICAGO, CINCINNATI, CLEVELAND, DALLAS, DETROIT, EL PASO, HARTFORD, INDIANAPOLIS, LOS ANGELES, PHILADELPHIA, SAN FRANCISCO

*"More than 100 factory offices throughout the world"*

BALL AND ROLLER BEARINGS

HOFFMANN

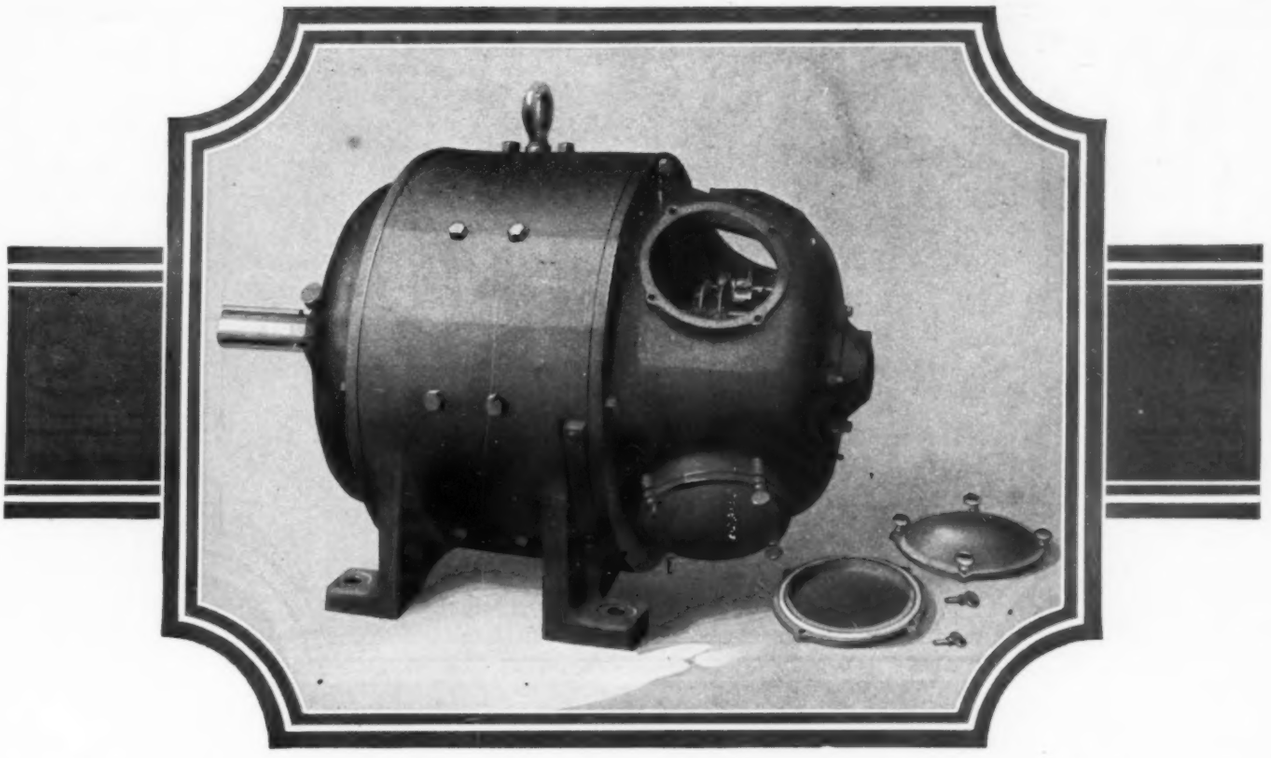
# PRECISION ROLLER BEARINGS

The replacement cost of a worn-out, burnt-out bearing is only part of the cost of such a bearing failure. Think of the "shut-down loss" involved—idle machine, idle men, idle investment, lost time, lost production.

The demonstrated "load-ability" of *"Hoffmann"* Precision Roller Bearings—even at high speeds and under hardest service—will protect you against these "shut-down losses." And their magazine lubrication with dust-and-oil-tight mounting makes them cleanly and practically neglect-proof.

Bulletin 904 explains the *"Hoffmann"* in its many types. Write for it.

*Our engineers are at your service, with a fund of useful experience in solving difficult bearing problems.*



Enclosed dust-tight and water-tight Type T Heavy Duty Reliance Motor for direct current, with anti-friction bearings.

# If you want them really dust-tight and water-tight—try this one

This enclosed type motor was developed for coke and sintering plants and for coal conveyors where the ordinary enclosed construction has not kept out all the dust.

Ball or roller bearings are used so that bearing housings are really dust-tight.

Back end brackets are solid. Front end brackets are solid with hand-hole covers. The seats for the covers are machined. The covers are machined and fitted with rubber gaskets.

These motors meet U. S. Navy requirements for water-tight motors. This test requires that a stream of water from a 1" nozzle under a head of 35 ft. be played onto motors for 5 minutes without leakage.

## RELIANCE ELECTRIC AND ENGINEERING CO.

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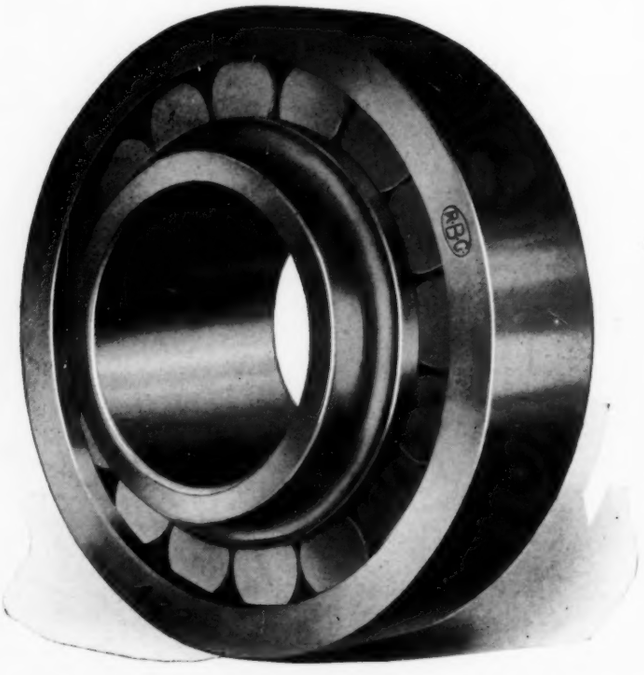
Branches: Boston, New York, Philadelphia, Pittsburgh, Cincinnati, Detroit, Chicago, Birmingham, Ala.

***We build both D. C. and A. C. Motors.***

Type T Heavy Duty RELIANCE MOTORS Direct Current

# NO

Lock Nuts
Thrust Plates
Adjustments
Loose Parts to cause trouble
Fussy Fits
Possibility of mismounting-both sides being alike



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is a FOOL PROOF Complete Unit.

## ROLLWAY BEARINGS

Are supplied complete with "ROLLWAY" Housings (patent applied for) for practically every make and type of heavy duty motor on the market.

Thousands of installations in service are demonstrating their superior ability.

## Rollway Bearing Co., Inc.

**Syracuse, New York.**

"V.V."

# V. V. Type DF Deadfront Switchboard

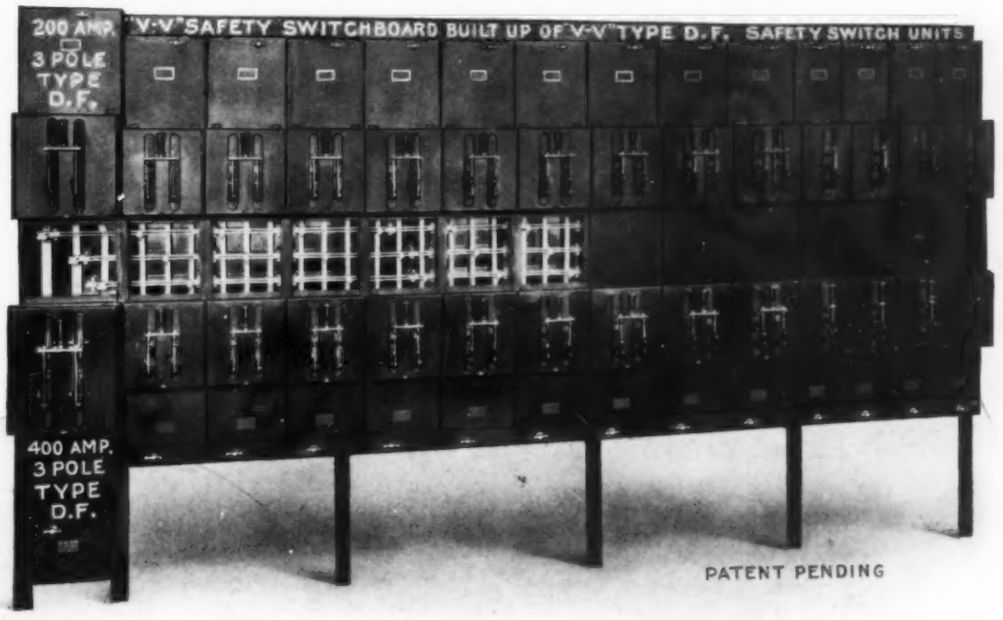
200 AMP. 3 POLE TYPE D.F.
"V-V" SAFETY SWITCHBOARD BUILT UP OF V-V TYPE D.F. SAFETY SWITCH UNITS
400 AMP. 3 POLE TYPE D.F.
PATENT PENDING

**Illustration Shows Some of Bus Compartment Covers Removed Showing the Systematic and Compact Arrangement of Distribution**

**The Ideal Absolutely Safe Deadfront Switchboard**

**All Live Parts Enclosed** **Fuses in Separate Compartments**

**Before Fuses are Accessible Switch Must Be Opened**

**Operating Handles on Front**

***Prices on Application***

# V. V. FITTINGS COMPANY

MAIN OFFICE AND WORKS

PHILADELPHIA, U. S. A.

**New York Office:** 50 Church Street **Chicago Office and Warehouse:** 710 West Jackson Blvd.

# ELECTRICAL DEVELOPMENTS

FOR THE

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You can expect the same superiority from our **Space Heater** for ordinary applications.

They were designed and are produced along the same basic lines—by the same ingenuity and skill that designed and produced the revolutionary Chromalox refractory sheathed units in various forms.

The adoption of Chromalox Strip Heaters for car heating on 1500 volts D.C. by the Illinois Central Railroad in connection with Chicago Electrification is proof of our claim that **Cromalox** leads the field.

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*The Trade Mark that stands for supreme quality and value. Look for it on your new space heater.*

**$1.75 each**

**$1.60 each, lots of 100**

**Space Heaters 2 feet long**

Shipment from Stock

SH-2150..500 watts-110 volts
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*The triple spiral insures ample durability and heat distribution.*

Our standard heavy duty Strip Heaters are recommended when severe conditions are to be met—70 catalogued heaters are carried in stock for your convenience from 8 in. to 36 in. in length.

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By the time your Packard transformers have served out their period of usefulness, you will be even more willing to concede the "honest value" that is in them.

The Packard Electric Company
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*Packard is never seen, except on goods of honest value*